THE AUGUST SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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This book attempts to stimulate the interest of the average freshman in the subject of animal biology so that he may be inclined to pursue it further in advanced courses. It deals primarily with the animal as a living organism.

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The authors have prepared this volume primarily for use in the undergraduate courses in deciduous fruit growing in agricultural colleges. Unlike many books on fruit growing, the problems of both tree fruits and small fruits have received attention.

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THE SCIENTIFIC MONTHLY

AUGUST, 1929

THE FIRST YEAR OF THE *CARNEGIE'S* SEVENTH CRUISE

By W. J. PETERS[1]

CARNEGIE INSTITUTION OF WASHINGTON

Just about one year ago the *Carnegie* left her prolonged berth in the Washington Channel with eight young scientists on board having ambitious visions of carrying out an elaborate program of observations under the leadership of Captain J. P. Ault. This article is based upon the numerous reports prepared by these young men at sea and compiled in the office. In reading these reports one is impressed with the glowing interest they contain, details of repeated trials with new apparatus, failures that will be overcome, successes already achieved—between the lines, hardships and possibly compensating amenities, for all of which there will be no room in this prosaic account of the work done during the first year of the three-year cruise of the vessel—her seventh—begun May 1, 1928.

Magnetic Work

The six preceding cruises of the *Carnegie* together with three of the *Galilee*, beginning in 1905 under the auspices of the department of terrestrial magnetism of the Carnegie Institution of Washington, had practically completed by 1921 a general magnetic survey of all the oceans, supplying values of the magnetic declination or variation of the compass, inclination and strength of the magnetic field over immense regions in which the navigator had hitherto been forced to rely on magnetic charts constructed on data altogether too meager. This comprehensive survey of the oceans together with contemporary magnetic surveys on land now furnishes material from which a fairly reliable theory of the magnetism of the earth as a whole may be deduced. Even so, changes occur, as the years go by, and charts, diagrams or investigations are made for one selected epoch in order to represent consistent values. Evaluations of the rates of these secular changes are not only required to reduce observed values to a common epoch or from one epoch to another, but they are in ever-increasing demand by investigators correlating the earth's magnetic field with other geophysical phenomena.

The present magnetic program[2] of the *Carnegie* has been planned accordingly to yield primarily, secular variation, and to obtain it with the least effort compatible with trustworthy results. This is accomplished—in part, by improvements in instruments, such as the installation of a constant-speed apparatus to drive the coil of the marine earth-inductor, an amplifier and a micro-ammeter to determine magnetic inclination—in part, by eliminating duplicate observations with two instruments—in

[1] Commander of the survey-ships *Galilee*, 1906–08, and *Carnegie*, 1909–14.

[2] See J. P. Ault, "The Purposes and Program of Ocean-Surveys," Scientific Monthly, 26: 160–177, 1928.

CARNEGIE UNDER SAIL

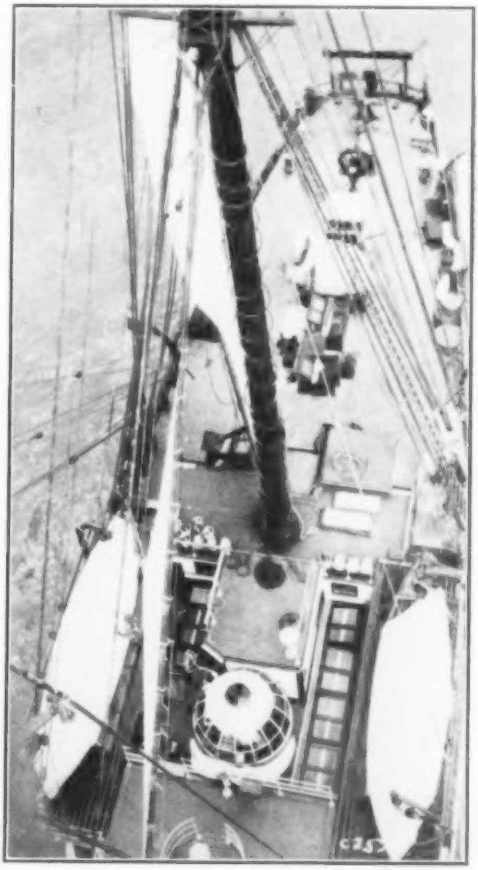
South Pacific Ocean (Latitude 2° South, Longitude 95° West).

part, by omitting observations every other day, or here and there as found desirable—and in part, by following the tracks of earlier cruises as closely as circumstances permit with the object in view of making every observation available for secular-variation data.

The passages already made by May 1, 1929, to a point beyond Apia are shown in the chart by the continuous line. The proposed passages of the rest of the cruise are shown by dotted lines. During the first year the vessel was actually at sea 242 days and had sailed 27,800 nautical miles (about 32,000 statute miles). She crossed the Atlantic, recrossed it, entered the Pacific by way of the Panama Canal, and after a loop in the southeastern Pacific to Easter Island, Callao and Samoa, had sailed from Apia on April 20, 1929, for Guam and Yokohama.

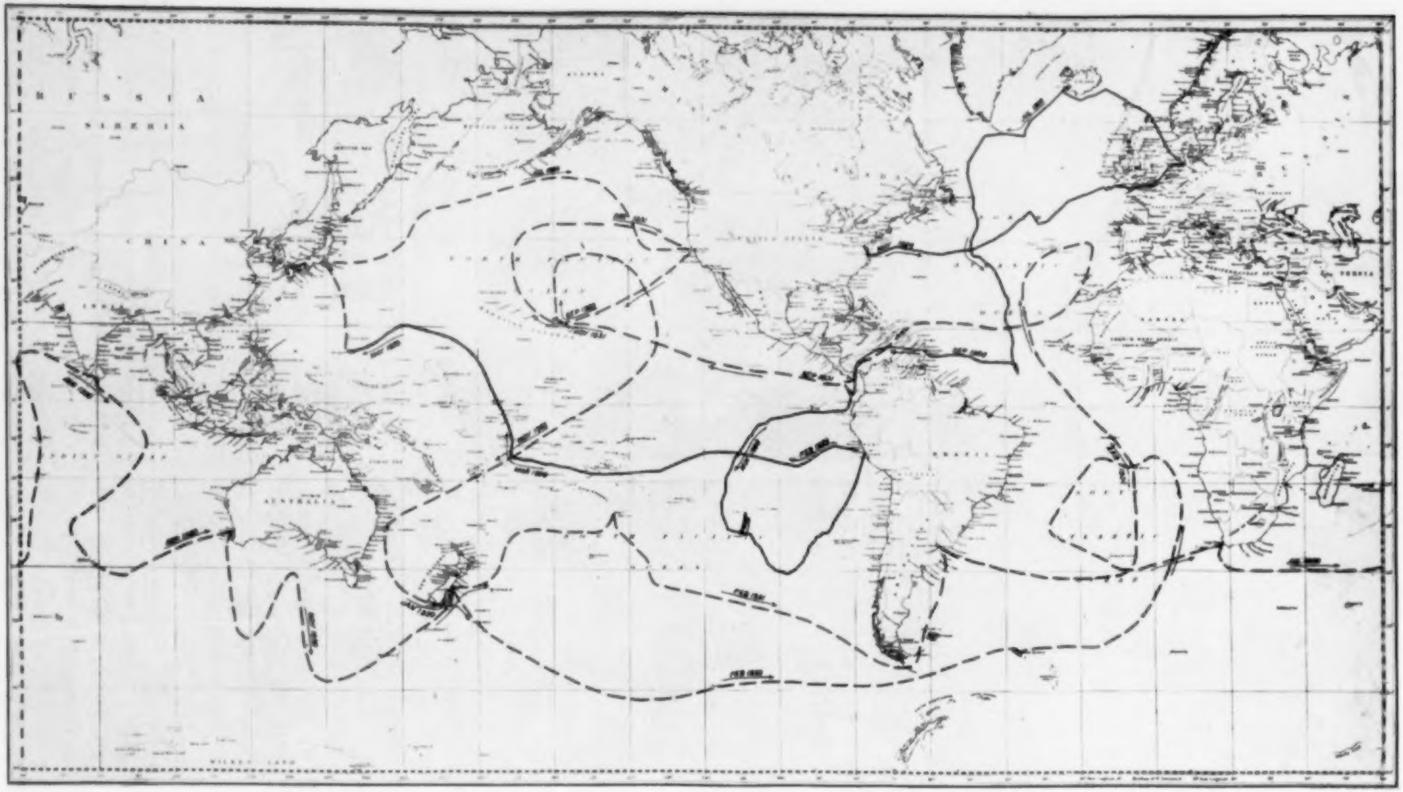
Atmospheric Electricity

Atmospheric-electric observations were not instituted with magnetic observations on the first cruise of the *Galilee*. Instruments and methods for use at sea were then far from perfect, and although observations were attempted on the third cruise (1907–1908) of that vessel and were continued on the subsequent cruises of the *Carnegie*, the more satisfactory instruments, largely of department design, not being available before the *Carnegie's* fourth cruise beginning in 1915. The end of the sixth cruise, therefore, left much to be desired especially in twenty-four-hour series and in the distribution of observations over the globe. Now by means of photographic methods continuous records of potential gradient can be made as long or as often as required. The apparatus is in a metal box bolted to the taffrail with a collector projecting outboard. The box is really a small darkroom with the recording parts inside. Another instrument for the photographic registration of conductivity will be installed in July after the *Carnegie* arrives at San Francisco to supplement the present eye-reading apparatus. Improvements have been made in the instruments for measuring penetrating radiation, radioactive content and conductivity, thereby offering through greater facility in operation many more opportunities for twenty-four-hour series.



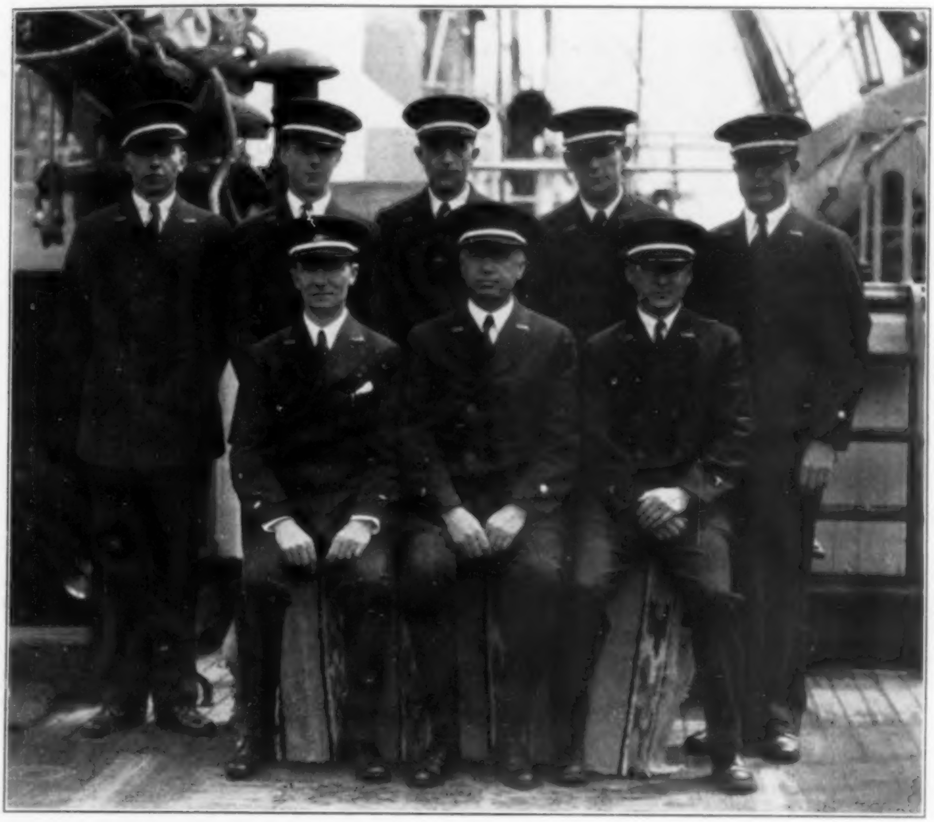
MAIN AND QUARTER-DECK, *CARNEGIE*
AS SEEN FROM ROYAL YARD.

Weather conditions were generally bad on the first passage, Hampton Roads to Plymouth, and some time was required for adjusting new instruments to service conditions and for devising a program that would fit in with other operations.



ROUTE CRUISE VII OF THE *CARNEGIE*, 1928 TO 1931,

FOR MAGNETIC, ATMOSPHERIC-ELECTRIC AND OCEANOGRAPHIC INVESTIGATIONS—CONTINUOUS LINES SHOW PORTION COMPLETED MAY 20, 1929; BROKEN LINES SHOW PORTION PLANNED 1929–1931.



SCIENTIFIC STAFF OF THE *CARNEGIE*
(*Left to right:* SITTING, PARKINSON, AULT, PAUL; STANDING, SOULE, JONES, SCOTT, SEIWELL, TORRESON.)

Low values of ionic content and conductivity were found and have been ascribed to stormy weather. At Hamburg, Dr. Kolhörster's penetrating-radiation instrument was received and is being used in observations parallel with the *Carnegie's* instrument.

Between Iceland and Barbados and subsequently observations have been made almost every day. Low values of ionic content and conductivity were obtained as far south as latitude 13° north, after which they were high for a few days before returning to normal on the westerly run to Barbados.

The Aitken dust-counter was used almost daily for nucleation-counts to correlate with atmospheric-electric elements.

METEOROLOGY

The meteorological program has been expanded to include continuous records with the Hartmann and Braun electrical recorder installed in the control-house with three pairs of distant resistance-thermometers, wet- and dry-bulb, the lowest in the shelter house on the quarter-deck, another at the main crosstrees and the highest just below the main truck. These thermograms, which are controlled by the Negretti and Zambra recording psychrometer on the Assman aspiration principle, will furnish data for temperature and humidity lapse-

RELEASING PILOT BALLOON ON BOARD *CARNEGIE*
SOUTH PACIFIC OCEAN

rates from practically the sea-surface to an elevation of about thirty-five meters.

Thermograms are also made for water-temperatures. The thermal element is attached outside to the hull about seven feet below load-water-line and the thermograph is installed in the new oceanographic laboratory.

Fine weather after leaving the canal gave the first opportunity to initiate pilot-balloon flights and to use the new gimbal-mounted theodolite received at Balboa from the navy. Flights were observed thereafter nearly every day during favorable weather, and on several occasions the balloon was kept in view for more than an hour, though the average time was from twenty to thirty minutes. The directions and velocities have been deduced from sea-level to heights of four to twelve kilometers in a region where few, if indeed any, pilot-balloons had ever been released. The new Plath drum-sextant received at Callao was found to be almost a necessity in team-work with the theodolite. The balloon was often picked up first with the sextant, the sextant-measured altitude then set off on the theodolite thereby expediting the pointing of the

theodolite after which simultaneous sights were taken, one for altitude, one for bearing, and the procedure was then repeated again and again.

The evaporation of sea-water is noted on days favorable for the experiment every four hours.

The foregoing are in addition to the customary meteorological observations which have always included hourly reports of wind-direction and wind-velocity, also state of weather and sea by the watch-officers; reports of wet- and dry-bulb thermometer readings and aneroid readings by the watch-officers at the change of watch; continuous thermograms in the shelter-house and barograms in the cabin; special meteorological observations in connection with any diurnal-variation series of some other investigation, usually by one of the scientific personnel, and the regular observations at mean noon Greenwich recorded on the Weather Bureau forms.

Oceanography

The work of deep-sea soundings includes several operations of sounding, subsequent electrical and chemical determinations and the calculations.

The sonic depth-finder was used in 331 soundings in the North Atlantic and again in the Pacific until the oscillator which is installed in the keel failed to function early in November. Then, as the microphones were still in good order an improvised gun made of brass tubing twenty feet long was used to explode shot-gun shells about a foot or so under water on starboard side, that is, on the side opposite to the microphones. The time-interval between explosion and echo was determined by a stop-watch. Sometimes the second echo was heard. A number of these soundings were compared with soundings by pressure-thermometer and with wire-soundings read on the meter-wheel corrected for the angle of drift. The oscillator was overhauled in dry-dock at Callao and has been functioning ever since.

About one hundred miles off the coast of Ecuador in latitude 1° 32′ south, longitude 82° 16′ west, a submarine ridge was discovered on November 8, 1928. This ridge is named "Carnegie Ridge." It rises about 1,800 meters above the general level of the ocean-floor which, here, is in soundings of 3,000 to 5,000 meters. A bottom-sample showed small fragments of lava and obsidian with globigerina-ooze. Another submarine ridge was discovered on January 8, 1929, extending twenty kilometers as the *Carnegie's* track crosses it and rising some 3,000 meters above the ocean-floor, which is more than 4,000 meters below the surface of the sea. In latitude 25° 03.2′ south, longitude 82° 20.0′ west, the crest of the ridge sounded in 1,445 meters and maintained this average level to 24° 54.0′ south and 82° 13.0′ west where it rose to a sounding of 1,260 meters before the final drop began. A bottom-sample showed grayish white globigerina-ooze. This ridge is named "Merriam Ridge" in compliment to the president, Dr. John C. Merriam, of the Carnegie Institution of Washington. It is assumed to be an extension of the uplift forming the islands of San Felix and San Ambrosio.

A deep was discovered on February 16, 1929, in latitude about 15° south, longitude 98° west, which was named "Bauer Deep" after the director, Dr. Louis A. Bauer, of the department of terrestrial magnetism. In a distance of fifty miles the observed depths varied from 2,700 meters to 5,400 meters and back to 4,100 meters.

A ridge rising 2,000 meters above the average bottom was discovered in the Tuamotu Archipelago.

Throughout the passage from Callao to Tahiti the bottom is very irregular, multiple echoes having been received indicating sometimes as many as six surfaces.

The technique of securing bottom-samples had been brought to a high state of efficiency on the Atlantic cruise, and as a consequence bottom-samples were obtained more frequently in the Pacific. The most successful device was the Vaughan snapper with thirty meters of four-millimeter aluminum-bronze wire for drift between the piano wire and the snapper, to prevent kinks in the piano wire after touching bottom. One of the *Meteor* tubes brought up on one occasion twenty-four inches of bottom material, but on a subsequent cast it stuck and was lost, the sounding wire breaking in the attempt to haul in.

All equipment for oceanographic stations is operating well. The Nansen water-bottles, stowed conveniently in racks built for the purpose on the quarter-deck, are quite successful, and the Richter and Wiese deep-sea reversing thermometers rarely fail to record properly. The salinity-apparatus after the design of Dr. F. Wenner, of the Bureau of Standards, for determining salinities by the electric conductivity is very satisfactory. When an oceanographic station has been made in the forenoon the values of salinity will have been determined by evening. That the accuracy of the results is high is indicated by occasional comparisons with results by titration. The reels of the bronze winch on the quarter-deck may be run singly or together, so that on oceanographic stations another wire may be payed out while one is being hauled in. Two series of water-bottles, ten on each line, can, therefore, be collecting at the same time, or a heavier line may be bent to the vertical tow-nets while a series of water-samples and temperatures are being obtained with the other reel.

Three bronze davits have been installed, one at the taffrail and one on either side just abaft the main rigging, with bronze fairleads for the bronze sounding wire. Water-bottles and thermometers are attached as the sounding wire leaves the fairleads by observers standing on outboard platforms. Two thermometers are used with each water-bottle, one unprotected and calibrated for pressure gives a check on the depth at which the temperature and water-sample are secured. Water-samples and water-temperatures are usually secured at each ocean-station practically every other day at the following depths in meters, 0, 5, 25, 50, 75, 100, 200, 300, 400, 500, 700, 1,000, 1,500, 2,000, 2,500, etc., to a lowest of 5,500 meters in two series using eight to ten bottles on each wire for each series.

PETTERSSON PLANKTON-PUMP READY TO GO DOWN

The calculations of density, dynamic depth, pressure, specific volume and their anomalies for the various depths are made on board in accordance with the method of V. Bjerkness (1910) as modified by Hesselberg and Sverdrup (1915). These are the data required for calculating the velocities of any layer of water from the surface down to the average depth reached. The number of solenoids down to a depth of 2,000 meters where the velocities are assumed to be zero is computed, a solenoid being formed by the intersection of surfaces of equal pressure (isobaric) with surfaces of equal specific volume (isosteric). The number of solenoids is a measure of the force tending to cause circulation. Preliminary reports on the results for the cruise in the North Atlantic and for passages in the southeastern portion of the Pacific Ocean (Balboa to Callao and Callao to Papeete) prepared by Captain Ault are being finally checked for publication. Two tables showing the observed and computed values of the various elements involved and graphs giving the details for temperature, salinity, density and specific volume are to be included in these preliminary publications. These graphs bring out many interesting facts, the details of which will appear in later communications. Preliminary publications are to be made in order that the data may be available for the use of students and investigators of oceanography at the earliest moment. This procedure is in accordance with our usual practice of publishing preliminary results in terrestrial magnetism. Even now the magnetic results obtained as far as Apia are either published or are in press.

The number of oceanographic stations between Washington and Plymouth was limited to six by heavy weather, adjustments of new equipment and the training of personnel. Two stations were made between Hamburg and Iceland and four more before reaching the Grand Banks of Newfoundland. During the stretch southward eleven stations were made before the westerly run to Barbados on which six more were made. At all stations but one, depths from 2,000 to 5,500 meters were reached.

The results in the North Atlantic confirm the conclusions presented by Helland-Hansen and Nansen in their book, "The Eastern North Atlantic," as regards the relation between observed values of temperature and salinity. The variations from a general curve are mostly accounted for by the presence of water of low salinity as compared with

APPARATUS ON TAFFRAIL OF *CARNEGIE*
FOR PHOTOGRAPHICALLY RECORDING THE POTENTIAL GRADIENT OF THE ATMOSPHERE.

REMOVING NANSEN WATER-BOTTLE AT OCEANOGRAPHIC STATION

temperature. For example, the presence of polar water is indicated at stations in the Greenland and Labrador streams. The results serve to emphasize the desirability of repeat-observations in the same localities for shallower depths in order to secure anything like an adequate view of the system of surface and near-surface circulation.

The records obtained between Balboa, Easter Island and Callao were made at five oceanographic stations in and near the Gulf of Panama, six stations along the westward stretch to about 105° west longitude past the Galapagos Islands, eight stations thence to Easter Island, six stations on the southeasterly run from Easter Island to latitude 40.5° south before heading up on the northeasterly stretch to Callao during which eleven stations were made. Captain Ault's preliminary reports state:

The charts, giving the results by these sections, present the physical conditions of the ocean water down to 2,000 meters in a very striking manner. The low-salinity fresh water near the coast is shown. Then we enter the high-salinity warm water, coming down from the central Pacific, before crossing into the cold, up-welling, turbulent waters of the sub-Antarctic as we approach the latitude of 40° S. The crossing of the Peruvian or Humboldt Stream is marked in the north off the coast of Ecuador, and again in the south as we approach the coast of southern Peru. Data from the next portion of the cruise will add materially to the picture of the physical conditions of the ocean waters of the South Pacific Ocean.

Marine Biology

The work in marine biology, confined mostly to microbiology to determine the abundance and distribution of plankton and other small organisms, has been carried on vigorously. The methods and apparatus are in large measure new; on the whole they have been satisfactory. The large plankton half-meter and meter tow-nets after the "Michael Sars" design with improvements and made of Dufour silk bolting-cloth are

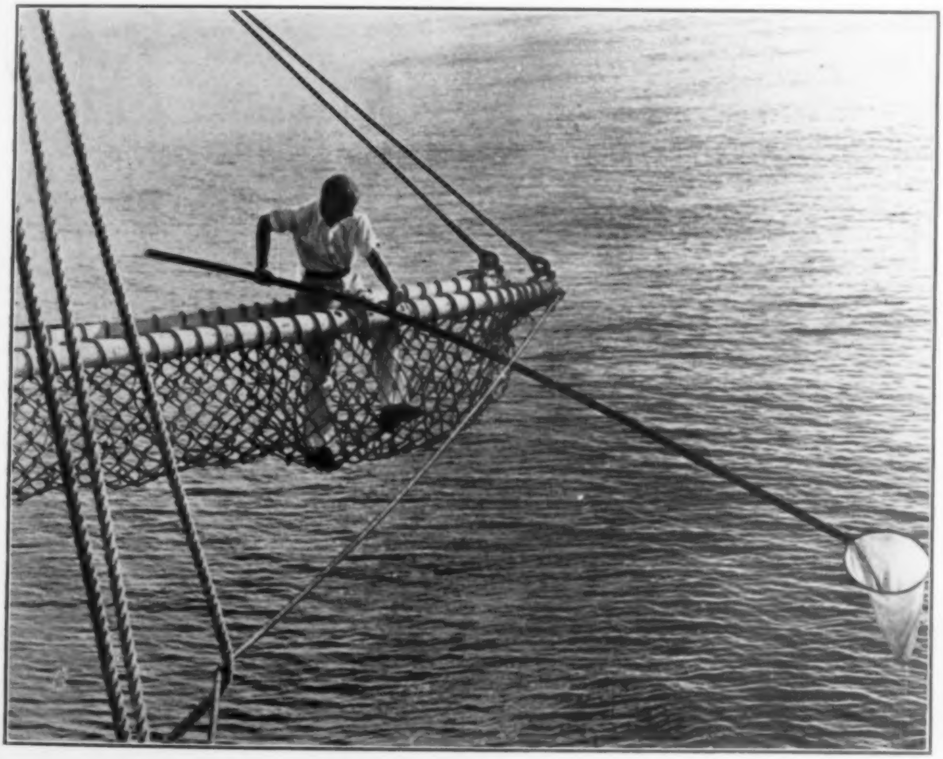
described by H. R. Seiwell,[3] chemist and biologist of the expedition, in the *Journal of the International Council for the Exploration of the Sea.*

The tow-nets are used at each oceanographic station at the surface, also at 60 and 120 meters below. The Pettersson plankton-pump is also used at the same depths. The nets have been generally satisfactory, except during excessive rolling when it is difficult to avoid tearing them. Experiments are being made with aeroplane shock-absorbing cord for the bridles. The last advices state that aeroplane rubber-rope bent to the inboard end of the towing line is being used with success.

Trouble with the Pettersson plankton-pump was also experienced when the vessel, hove to, was rolling heavily, but a number of adjustments and improvements made at sea now render this instrument serviceable under almost any condition likely to be encountered. The quantitative plankton-pumpings obtained with this instrument are considered to be the best ever made on the high seas, and they will show, when worked up, the relation between the zooplankton and the phytoplankton to 100-meter depths. A large amount of biological collecting is done with tow-nets and dip-nets dragged from a special boom-walk similar to the one used by Beebe, which is lowered by a pendant from the starboard fore-rigging. This boom-walk enables the collection to be made well out from the wash of the vessel.

In addition to the biological work concerned chiefly with the plankton, ocea-

[3] See *J. Conseil Internat. pour l'Exploration de la Mer,* 4: 99–103, 1929.



USING DIP-NET FROM THE BOOM-WALK OF *CARNEGIE*

sional tows and dredgings are made in shallow water for diatoms and *Foraminifera*. The chemical studies in inorganic phosphate, nitrate and hydrogen-ion concentration are intimately tied up with the phytoplankton.

The advantages of receiving radio time-signals and the almost daily communication with the office can hardly be overstated. The uncertainties in the rates of five or six chronometers carried on the earlier cruises made it necessary to postpone final corrections to the longitudes of sea stations until time-signals could be obtained at the next port. Now final longitudes are obtained on the day following the stations for which they are required, with a vast reduction in the work of comparisons and computations.

All preliminary computations are made and checked on board and are promptly mailed to the office with all records at each port.

During the first year of the present cruise there have been made 350 magnetic declination-observations, 110 inclination and horizontal-intensity observations, 98 oceanographic stations, 800 sonic-depth determinations, 225 atmospheric-electric observations, 90 balloon-flights and 50 collections of bottom-samples, besides the daily and continuous records of air and water-temperatures, of humidity and of pressure.

The scientific staff of eight are: Captain J. P. Ault, commander and chief of scientific staff; Wilfred C. Parkinson, senior scientific officer; Oscar W. Torreson, navigator and executive officer; F. M. Soule, observer and electrical expert; H. R. Seiwell, chemist and biologist; J. H. Paul, surgeon and observer; W. E. Scott, observer; Lawrence A. Jones, radio operator and observer. Dr. H. U. Sverdrup, of the Geophysical Institute, Bergen, Norway, research-associate of the Carnegie Institution of Washington, is consulting oceanographer.

The preparations for the current cruise had and have generous cooperation, expert advice and loans or donations of much special equipment and many reference books on board, from government and private organizations and individuals interested in oceanographic research both in America and Europe. For these the Carnegie Institution of Washington is indebted to many organizations at home and abroad.[4]

From considerations of the data already obtained and above briefly noted, it is believed that Cruise VII of the *Carnegie* will yield much valuable material to enrich many branches of geophysical research. It is hoped that the development of technique, the improvements of apparatus and methods and the results obtained during the cruise may be helpful in stimulating and may serve as a general basis for future intensive surveys in the vast oceanic areas.

[4] For a detailed list of these organizations and individuals see J. A. Fleming and J. P. Ault, *Zs. Ges. Erdk.*, Ergänzungsheft 3: 55, 1928.

WAVE MECHANICS

By Professor C. F. HAGENOW

WASHINGTON UNIVERSITY, ST. LOUIS, MISSOURI

PROBABLY no modern theory of the atom, since Bohr, has attracted more attention or been more often mentioned than the Schrödinger theory. This is to be explained, of course, mainly by the fact that it is the only one which, even in a limited degree, lends itself to a representation by physical models. This theory, however, from its very nature, is a logical part of a more general topic that goes by the name of wave mechanics. The object of this article is avowedly to deal with this topic only in a very broad and general manner.

Dr. Karl K. Darrow,[1] after referring to those physicists who "yearn for continuity in their images of nature," remarks that the theory of wave mechanics "has captivated the world of physics in a few brief months because it seems to promise a fulfilment of that long-baffled and insuppressible desire." The old saying regarding the pendulum swinging to the other extreme is remarkably exemplified in the general aspects of this new theory of the atom. For, while the older quantum theory sought to replace our time-honored wave-motion by corpuscles of energy, this theory requires just the reverse, since now the ultimate particles of matter are themselves regarded as systems of waves of a certain sort.

This is really an extraordinary reversal of view-point, for the whole trend of physical science has been in the direction of atomicity. Among the earliest Greek philosophers we have our atomists, such as the famous Democritus, though the atomic theory of matter can scarcely be called a scientific theory until Dalton provided it with an experimental substratum many centuries later.

It seems but yesterday that we spoke of an "electric fluid," or of two of these fluids. Now this mysterious fluid has gone the way of all matter and has become granular, with the exceedingly fine grains, *i.e.*, electrons, that Millikan has measured so accurately. Students often call them "discreet" (discrete) particles, but it seems to-day as if these particles have not always been "discreet" enough, for a number of our experimental physicists have recently detected them in a most unparticle-like behavior, a subject to which we shall revert later.

Next we were asked to consider the possibility of light being propagated as corpuscles. The fact that a corpuscular theory of light had been the prevailing theory for a century after Newton made matters all the worse, for it seemed too much like a ghost-walking business. This particular ghost, *viz.*, the corpuscular theory of light, was one that was thought to have been laid for all time. Experiment after experiment, in all branches of optics, fitted in so perfectly with the wave theory of light that Hertz could say in 1889, "The wave theory of light is, humanly speaking, a certainty."

Unlike their predecessors, the light corpuscles, these waves required a medium in which to travel, and a "luminiferous ether" was provided. There is a certain naïveté in the very choice of this adjective which was not lost on a certain prominent president of the British Association for the Advancement of Science a generation ago, who remarked that the chief function of the ether was to furnish the subject for the verb "to undulate." Yet it is characteristic of the philosophic attitude of that time that it could seriously be said, "There is as much reason for believing

[1] "Introduction to Wave Mechanics," *Bell System Technical Journal*, 6: 653. 1927.

in the existence of the ether as in that of shoemaker's wax."

One of the chief trouble makers of the supposedly firmly established wave theory is the *photoelectric effect*. Photoelectricity was genially defined recently by a physics student as "the production of a photo by means of electricity through light rays." The discerning reader will doubtless perceive that we have to do with a phenomenon widely applied in the transmission of photographs and television. The basic phenomenon is simply that of the liberation of electrons from certain metallic surfaces when the latter are struck by light of appropriate wave-length. This has often been described, and is mentioned here only to call attention to the fact that a corpuscular theory of light is imperatively demanded by certain experiments connected with this emission of electrons by metals when illuminated with the proper wave-lengths. Thus the energy with which the electrons are emitted is entirely independent of the intensity of the incident light, but depends only on the frequency vibration of that light. A spreading, and therefore constantly attenuating, wave will simply not provide energy enough. What is required is particles that conserve their energy *regardless of the distance they have traversed before striking the emitting surface*. As Sir William Bragg has so vividly illustrated this point:

> It is as if one dropped a plank into the sea from a height of 100 feet and found that the spreading ripple was able, after traveling 1,000 miles and becoming infinitesimal in comparison with its original amount, to act upon a wooden ship in such a way that a plank of that ship flew out of its place to a height of 100 feet.

Now this new hypothesis contains another yet more startling implication. For if light, or more generally, radiation, is propagated as corpuscles, so is the energy that this radiation represents. The amount of energy in each of these little "parcels" is expressed by the product of two factors, namely, the frequency of vibration of the radiation and the world-famous universal constant known as Planck's h. Algebraically expressed it is $h\nu$, the "quantum" of energy. Of course, the magnitude of the quantum may vary. Thus a quantum of radio radiation is much smaller than a quantum of visible light, and an X-ray quantum is larger still.

We have thus arrived at the end of an "atomizing" process. Matter, electricity, light, energy—all seem to be made up of exceedingly small, but finite, particles. What is left? The ether? With light and energy shot out as corpuscles, what need have we of an ether? Under these conditions one may well ask, with respect to the new wave theory of matter, where and how did such a revolutionary, or rather counter-revolutionary, theory arise? New as it is, however, it can boast of a very aristocratic ancestry of ideas and principles.

Here, again, we are delving into the past and are about to work over old material. Without going into mathematical details, it must suffice to state that nearly a century ago Hamilton developed certain relations between the motion of a particle and a wave-motion, relations that have been elaborated and extended by Louis de Broglie and Schrödinger in a truly remarkable, not to say startling, manner. Guided by a certain striking resemblance between two famous theorems dating back to Huygens and Maupertuis, de Broglie proposed a bold hypothesis to the effect that there is associated with every particle of matter a wave-motion such that the relation between the motion of the particle and that of the accompanying wave can be expressed by the equation

$$uv = c^2,$$

where u is the velocity of the wave, v the particle velocity and c the velocity of light *in vacuo*. Relativity also enters

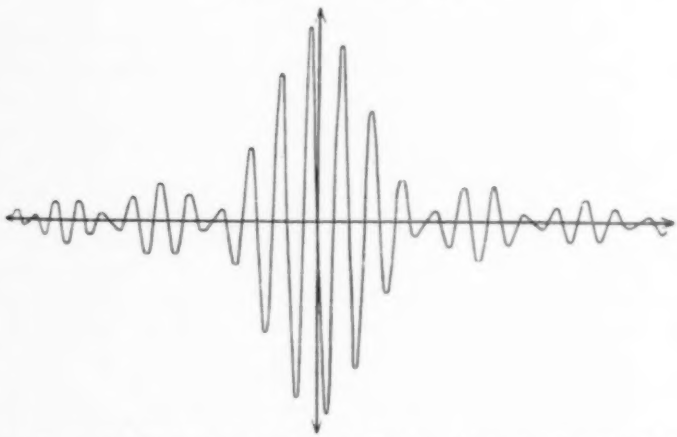


FIG. 1. FROM "DIE NEUE MECHANIK," BY LUDWIG FLAMM, *Naturwissenschaften*, 15: 569. 1927.

in, but the details must be omitted here.

But a serious obstacle seems to present itself at this stage. For, since in the relativity theory no material particle can have a velocity greater than that of light, it is easy to see from the above equation that if v is less than c, u must be greater than c. Thus the hypothetical wave associated with the particle would travel faster than light itself.[2] However, the difficulty vanishes when the "group velocity" of these waves is taken into consideration. What is meant by group velocity can best be explained by referring to a phenomenon that can actually be observed on a water surface. Drop a stone into still water; the resulting wave soon becomes a group of waves of different wave-lengths and velocities. The crest of this group moves out with a certain velocity while the individual waves pass through it (in this case with greater velocities) from rear to front. More abstractly, whenever a number of waves of various wave-lengths are traveling through a medium in which the velocity of propagation varies with the wave-length, then that part of the combination in which the various waves are most nearly in phase (in step) with each other, *i.e.*, the maximum amplitude, will itself move along with a velocity different from that of any of the constituent waves. It may be well to point out that this group velocity is also the velocity with which the energy of any wave propagation is transported. Figure 1 represents such a group, the crest shown by the arrowed line. A very short distance on each side of this peak interference rapidly decreases the amplitude of the group.

Another illustration of this phenomenon familiar to physicists is furnished by the behavior of light in carbon disulphide. Michelson, by actual measurement, found the ratio of the velocity of light in air to that in carbon disulphide equal to 1.77. On the other hand, the index of refraction of carbon disulphide is only 1.64, which is to say that the velocity of light in air should be 1.64 times as large in air as in the liquid. This discrepancy of 7.5 per cent. is entirely accounted for by the fact that the group velocity of light in carbon disulphide (which is what is measured by the revolving mirror method) is 7.5 per cent. less than the wave velocity, which is the one that determines the index of refraction.

To return to the waves associated with the moving particle, calculation shows

[2] Not the first instance of the appearance of a "super-light velocity" of wave propagation in theoretical physics; *e.g.*, light propagation in some metals is attended by such velocities.

that the *group velocity* of the "super-light velocity" waves comes out exactly equal to the *particle velocity.* We have, then, this situation: *A moving material particle can be thought of as being connected with a vibration whose wave velocity exceeds that of light, but whose group velocity (the energy carrier) coincides with the actual velocity of the particle.* Referring again to Figure 1, we can now look upon this group of waves as a sort of model of what is called a "wave-corpuscle."

We come now to a very important feature of the theory, namely, the consideration of the energy of this wave-corpuscle. Since it partakes of the nature of both a material particle and a wave system, we can express its energy according to these two aspects. Naturally these two expressions of the energy must be equal to each other, and this equality constitutes de Broglie's basic assumption. Let us take first the energy of the particle considered as a vibration. This energy is expressed by the product $h\nu$, where ν is the frequency of the vibration and h is the Planck constant. The reader is doubtless not entirely unprepared to meet again with this h in the expression for an energy of vibration. One simply can not get along without it. Like the "Leitmotif" in a Wagner opera, it bobs up again and again, reminding us that in some mysterious way it plays a central rôle in every physical phenomenon.

Next consider the energy of the particle as a bit of matter. This is not the energy due to its motion or position (*i. e.*, kinetic or potential energy) but its *intrinsic* energy considered simply as mass, that is to say, a certain quantity of matter. The amount of this intrinsic energy, according to Einstein, is expressed by the product of the mass and square of the velocity of light *in vacuo.* Thus if one gram of matter could all be converted into energy it would yield 9×10^{20} ergs of energy. If this process of converting matter into energy could be realized in practice, our fuel problem would be solved once for all. For example, suppose some one in King Tut-ankh-Amen's day had started an engine with just one ounce of "fuel" that could be gradually converted into mechanical energy at a rate to keep the engine running without a stop with an output of thirty horse-power. The engine would be going yet, with some three hundred years to run before this ounce of matter would be entirely consumed.

We can now write de Broglie's fundamental assumption, which is, as remarked above, the statement of equality of the energy of the moving particle as calculated from the two view-points, namely, as a vibration and as a mass. He puts

$$h\nu = mc^2. \qquad (1)$$

Now, using the well-known relation between velocity, frequency and wave-length,

$$u = \nu\lambda,$$

we have

$$\lambda = \frac{hu}{mc^2}$$

and finally, since

$$u v = c^2,$$

$$\lambda = \frac{h}{mv}. \qquad (2)$$

Here is a surprising result. *The wave-length associated with a mass, m, moving with a velocity v, is given by Planck's h divided by the momentum of the particle.* (The reader is now in a position to figure "the wave-length" of his car as it bowls along the highway!)

De Broglie applied his theory to the atomic orbits of the Bohr theory and derived, in a very natural manner, many of the results of the latter theory that were obtained earlier by more or less arbitrary assumptions. The question of the "naturalness" of these derivations is debatable. It may almost be said to be a matter of the reader's temperament or taste. A friend who is especially well

versed in wave mechanics remarked: "It may be true that de Broglie's additional assumptions may be more natural than those of Bohr. As for myself, I am undecided just which of the two is the better conjurer."

But one does not ask for the credentials of a theory; the first question is, can we put it to the test of experiment? If this particle travels along disguised, as it were, as a group of waves, what will happen if it should pass very near some obstacle, or through a narrow opening? The reader may perhaps have observed the behavior of fairly large water waves as they pass by an obstacle, for example, the curves of a pier or breakwater. The wave, as it passes, will be seen to curve into the region *behind* the obstruction. The same phenomenon occurs in the case of light and sound. We are not surprised to hear around a corner, and light waves behave in a similar manner provided the obstacles are small enough in proportion to the very small dimensions of a light wave. When you next look at a distant light through a Pullman screen or through the covering of your umbrella, notice the patchwork of light and shadow that constitutes the "diffraction pattern," which is all the image of the source of light you will be able to see under the circumstances. The actual outline of the light is almost entirely destroyed by the confusion of the multiple images produced by the "diffraction" (bending around) of the light waves. This phenomenon is an essential characteristic of all wave propagation, and a moving particle might be expected, on the above theory, to manifest some sort of diffraction effect when very near obstacles of comparable size.

Such an effect was, indeed, found to be present in the case of moving electrons by Davisson and Germer[3] a short time ago. They showed that electrons impinging on nickel crystals were diffracted very much like X-rays. This looks like a most promising step in the direction of the much-desired harmonization of the outstanding conflict between the wave theory and the corpuscular theory of radiation, truly a "consummation devoutly to be wished." Unfortunately we are still confronted, at this stage at least, by a serious discrepancy existing between the two cases, *i.e.*, between the diffraction of light and the diffraction of electrons. If light *is* corpuscular, then corpuscles, or "photons" as they are called, do not affect one another in their respective paths, as do electrons, since electrons in motion constitute electric currents and these do interact in the well-known manner.

Before taking up the Schrödinger theory let us review very briefly some of the elements of the Bohr theory of the atom, the very one that these later wave-mechanics theories are designed to supplant. It is essential that the reader have a clear notion of some of the features that any theory of the atom must be able to explain. One of the most important of these features is a "physical picture," with its attendant mathematical formulation, that will yield correctly the wavelengths or frequencies of the spectral lines of the elements.[4] According to the Bohr theory, the frequency of a particular spectral line is given by

$$\nu = \frac{E_1 - E_2}{h},$$

where E_1 and E_2 denote the energy values, respectively, that are associated with two orbits of an electron, such that radiation of frequency ν is emitted when the electron falls from one orbit into the other. For definiteness let us think of the hydrogen atom with its one electron. No emission occurs while the electron

[3] A very interesting account by Dr. C. J. Davisson will be found in the SCIENTIFIC MONTHLY for January, 1929. Also, by the same author: "Are Electrons Waves?" *Jour. Franklin Inst.*, 206: 597. 1928.

[4] It must be confessed, however, that in recent years the physical picture threatens to become obsolete; not so much because the theorist is more inclined to dispense with it, as because such a physical model is often quite impossible.

revolves in any one orbit, and we say, then, that the electron is in one of its *stationary states.* Moreover, Bohr assumed that only certain orbits were possible for the electron, namely, those for which its angular momentum about the nucleus was equal to a *whole number* multiple of $\frac{h}{2\pi}$. Denoting the mass of the electron by m, its velocity by v and the radius of the circular orbit by r, this assumption states that

$$mvr = \frac{nh}{2\pi},$$

where n is always a *whole number.* That is to say, the orbits or stationary states have been "quantized." Of course no one knew (or knows now) *why* these orbits should be so restricted, but the theory "worked" and one is reminded of the saying: "Nothing succeeds like success." However, the point to keep in mind is this matter of "quantization." I might substitute the older term, used earlier in this article, and call it "atomization." Nature seems to work that way,[5] and the theorist racks his brains for a more or less plausible theory to make the process seem "natural." Some great mathematician, I believe, once said something to the effect that nature had no regard for analytical difficulties.

Now the Schrödinger theory proposes to educe this quantization from certain basic mathematical principles, thus dispensing with a special postulate toward the desired end, as in the case of Bohr. As Schrödinger himself states, "The essential thing is that this quantization no longer appears as a mysterious 'Ganzzahligkeitsforderung' (whole number requirement), but is carried a step further back, as it were, finding its basis in the finiteness and uniqueness of a certain space function." This sounds rather abstract and is intentionally so on Schrödinger's part, but certain analogies can be attempted for sake of a clearer comprehension. The new theory is partly based on the same principles de Broglie employed, and in his first paper on the subject Schrödinger gracefully acknowledges his indebtedness to the French physicist.

It is impossible to give a physical picture of the theory as a whole, principally because it is, in essence, mathematical, and much of the mathematics does not lend itself to physical representation by means of models. Like de Broglie, Schrödinger also associates a vibration with the electron but he develops this vibration into a standing wave instead of the moving or advancing wave of his predecessor. An illustration of standing or stationary[6] waves is, fortunately, easily supplied. Consider the vibration of an ordinary violin string, for instance. When plucked or bowed, it assumes the familiar spindle-shaped form shown in Figure 2. Since all points

FIG. 2

of the string move up and down in step (though not through the same distance) this form of wave-motion is described as stationary or standing waves. Again, when the violinist places his finger lightly on the middle of the string, the first overtone or harmonic is sounded, and the string appears as in Figure 3. The frequency is, of course, twice that

FIG. 3

[5] The famous "Natura non facit saltum" seems to have followed the "horror vacui" into desuetude.

[6] This term is here not synonymous with "stationary" as used in "stationary states." The latter use of the word was no doubt suggested by its earlier application to this type of wave-motion. As will be seen further on, these stationary waves *do* correspond to stationary states in the Schrödinger theory.

of Figure 2, *i.e.*, the tone is an octave above the first one. Similarly we can have three segments, or loops, with three times the fundamental frequency, and so on.

Now this picture is of special interest just here as it brings out clearly the fact that, in order to have a well-developed system of such standing waves, it is indispensable that the length of any of the equal segments be an aliquot part of the length of the string, or, in other words, only those frequencies are emitted which are whole number multiples of the fundamental frequency shown in Figure 2. Describing this state of affairs in modern terms, we say that the frequencies of the vibrating string have been "quantized." Each of these modes of vibration, emitting its characteristic frequency, corresponds to the various orbits of the electron in the Bohr model of the hydrogen atom discussed above.

Employing, for the sake of illustration, such a vibrating string as an extremely simple atom model, we should describe the situation as follows: No radiation is emitted while the atom is in one of its stationary states, *i.e.*, in one of its states of a single characteristic vibration. But suppose two such characteristic vibrations to occur simultaneously. In the language of acoustics, a beat frequency would result; a radio fan would call it a heterodyne frequency. Now it is this beat frequency that constitutes the frequency of emission. Since the number of beats per second produced by two tones is equal to their frequency *difference*, it is obvious that this conception of Schrödinger is mathematically equivalent to the Bohr equation for emission. For we had, on page 113,

$$\nu = \frac{E_1 - E_2}{h},$$

or

$$\nu = \frac{E_1}{h} - \frac{E_2}{h},$$

the two terms on the right corresponding to these simultaneous stationary states of vibration. Thus we have in the Schrödinger atom a coexistence of two states of vibration while the atom is radiating, while in the Bohr atom radiation takes place during a transition from one stationary state to another. Schrödinger thinks of this coexistence as taking place while energy is being transferred from the one vibration to the other.

Unfortunately, this simple picture is quite inadequate for the complete representation of a system which is even simpler in structure than a hydrogen atom. When we attempt to picture a hydrogen atom, the situation becomes still more complicated. The "waves" lose all reality. And yet, in the remarkable experiment of Davisson and Germer mentioned above, the waves associated with a moving electron seemed real enough. We have indeed traveled a long way from our "billiard ball" atom of old!

No discussion of the Schrödinger theory would be at all recognized as such without some mention of his famous symbol "ψ" which, in one instance at least (I was told), had "broken" into the editorial page of a metropolitan newspaper. This symbol appears in many guises—I had almost said disguises. In the extremely simple case of the vibrating string, discussed above, it may represent simply the instantaneous displacement of the particles of the string from their position of equilibrium. But the atom is composed of electric constituents, and the so-called vibrations are not to be thought of as mechanical motion, but as electrical fluctuations of some sort. Considering only the hydrogen atom, Schrödinger found good agreement with experiment (*e.g.*, measurements on the relative intensities of spectral lines) by putting the square of the amplitude of ψ equal to the density of the electric charge, in this particular case the charge of the electron. But, mathematically, ψ has a value throughout space, hence the

electron must occupy all space! However, calculation shows that practically the whole charge of an electron is concentrated within a sphere of the order of 10^{-8} centimeters diameter, which is, in fact, the atomic magnitude. Such an agreement can surely not be a mere accident. It is the *fluctuation* of this electrical density which determines the character of the emitted radiation corresponding to the interorbital jumps of the electron in the Bohr atom. On the other hand, a *constant* electrical density is unaccompanied by emission, being therefore a stationary state, just as the revolution of the electron in any one orbit constitutes a stationary state in the Bohr atom.[7]

But this simple picture must again be abandoned when more complicated systems are considered and ψ becomes more and more a mathematical abstraction. There seems to be a tendency away from "physical pictures." Our imaginary atomic machinery is necessarily suggested by our experience with large-scale objects and their relation, and it would be strange indeed, it seems to me, if such structures were found to be workable in all respects in an alien atomic world. The argument has even been advanced, notably by Heisenberg, that we should definitely renounce all attempts at such picturization, *e.g.*, the position and orbital velocities of electrons in the atom, since we can never hope to verify them by experiment. We should work only with those quantities that are directly observable, such as the frequency and intensity of spectral lines. Heisenberg's "quantum mechanics" bears witness to the successful application of this principle. Yet there are still other ultramodern rivals of the Schrödinger theory. One wonders if this period of almost feverish activity has its equal in the whole history of physics.

[7] The reader is cautioned that this varying electrical density is of a purely theoretical character and not susceptible of direct measurement.

STUDIES IN EXPERIMENTAL EMBRYOLOGY BASED ON SEA-URCHIN EGGS[1]

By Dr. D. H. TENNENT

RESEARCH ASSOCIATE IN BIOLOGY OF CARNEGIE INSTITUTION OF WASHINGTON

THE living organism is unlike any mechanical contrivance in that it can reproduce itself. It is self-perpetuating.

The essential reproductive cell is the egg. The egg may be regarded as a detached portion of a living organism, specialized for the purpose of reproducing its kind and bearing the characteristic organization of the species to which the individual producing it belongs. This organization is inherent in the egg and is preserved through each generation. We can say little regarding the precise nature of organization. We know, as Von Baer knew, that the embryo is not preformed in the egg, and we know, as he knew, that it does not come from an undifferentiated mass.

The egg is a cell. Its cytoplasm is maternal in origin; its nucleoplasm, when biparental development is concerned, has come from the father and the mother of the individual producing the egg. In many organisms it is possible to trace the germ cells back to the cleavage stages of the egg. In the sea-urchins the earliest stages of eggs that have been observed are small cells in the wall of the sac-like ovary. These germ cells, potential ova, are ameboid in form. They contain a nucleus and homogeneous protoplasm. It seems probable that the living primordial germ cell is simply a bit of undifferentiated protoplasm, living substance, with its nucleus. At this stage nothing in the nature of formed components, inclusions, may be seen within it. As the growth of the cell proceeds, substances are taken into it from surrounding cells and it increases in size, the increase in size being due in part to the increase in amount of living substance and in part to the formation and inclusion of nutritive materials, deutoplasm, stored for the needs of later development.

One may distinguish between living substance (protoplasm), included materials (deutoplasm) and transitional stages between these two, each being the end product of a reversible reaction.

The included substances are organic compounds formed as a result of interaction between nucleus and cytoplasm. With the microscope one does not see the actual formation of these compounds. They become visible only after the aggregations have become big enough to be seen with the microscope; *i.e.*, when they have reached a size above 100 mμ. If one makes use of the ultra microscope still smaller particles may be seen. Secondary colloidal particles are said to range in size from 5 to 100 mμ. Finer and finer subdivision beyond the limits of any direct observation is conceivable.

Lyon found that by centrifuging sea-urchin eggs it was possible to produce stratification of visibly different substances. The work of Conklin, Morgan and others showed that centrifugalization did not modify the organization of the living substance. Formed components, inclusions, were moved through the living substance without destroying its integrity, without changing its organization.

What do we know of the organization of the egg?

In the sea-urchin egg a micropyle may be demonstrated. This is at the "animal" pole of the egg. It is at this point that the polar bodies are always

[1] A lecture delivered before the Carnegie Institution of Washington, April 16, 1929.

formed. The "vegetal" pole is the opposite pole of the egg. The principal axis of the egg may be regarded as extending through the egg from pole to pole.

The egg has polarity. The anterior end of the larva always coincides with the animal pole of the egg; the micromeres, and in turn the mesenchyme cells, are always formed at the vegetal pole. The egg seems to carry as an inherent quality the polarity of the organism from which it came. Boveri and Driesch referred polarity to the polarization of the ultimate structural particles of which the ooplasm is built.

Polarity is basic. It is the fundamental feature of organization. Historically, with the establishment of polarity the major axis of the embryo is determined. What is the next step? Does it lie in the separation of organ-forming materials or is there some more general and fundamental feature of organization?

It is commonly assumed that the sea-urchin egg is radially symmetrical around the egg axis. Is this a fact? When is bilaterality established? Is it induced from the outside or does it exist in the unfertilized egg? What determines the bilaterality of the parthenogenetic larva?

It is conceivable that symmetry is a fundamental attribute of organized material, secondary only to polarity, and that the establishment of minor axes incident to bilaterality is the first step in the cytoplasmic differentiation of the larva, taking precedence historically over the processes of differentiation of organ-forming materials.

Thus far we have made rather general statements. Their significance will become more apparent when they are specifically applied to material on which investigations have been made.

Boveri found that in the eggs of the sea-urchin *Paracentrotus* scattered pigment became concentrated, during maturation, in a ring-like zone lying in the vegetative half of the egg and standing at right angles to the axis of the egg. He concluded that the three zones made evident in the ripe egg by the pigment ring correspond to the three primitive organs of the larva; the vegetative, unpigmented cap furnishing the primary mesenchyme and therefore the larval skeleton, the pigmented zone containing the material for the digestive tract, and the unpigmented animal half of the egg providing the material for the ectoderm and its differentiations. His results led to the generally accepted inference that a similar zone exists in the eggs of other sea-urchins, although it is not made visible by the localization of pigment, and that this zone separates the animal half, containing potential ectoderm, from a vegetative cap of micromere-forming material.

This segregation of materials in the unfertilized egg and the fact that the materials thus segregated were separated from each other during the first four cleavages of the fertilized egg seemed to constitute a demonstration of epigenetic development prior to fertilization.

Early in the course of an investigation on eggs of the sea-urchin *Lytechinus* at the Tortugas Laboratory, work done in collaboration with Dr. C. V. Taylor and Dr. D. M. Whitaker, a report of which has recently been published by the Carnegie Institution, it was found that in the *Lytechinus* egg there is no completeness of separation of potential germ layers prior to fertilization. The work involved the cutting of the eggs with glass or quartz needles, under the microscope, into two fragments, each of which was subsequently fertilized. The eggs were carefully oriented and the cuts made either in a plane at right angles to the principal axis of the egg, in a plane parallel to it or in a plane intersecting the principal axis obliquely. The eggs were cut accurately, cleanly,

in any desired plane, and into fragments of any desired relative size.

The two fragments, one containing the egg nucleus, one without a nucleus, were then washed, placed in small dishes and fertilized. It is evident, therefore, that after fertilization the nucleated fragment will contain a fused egg and sperm nucleus, and that the non-nucleated fragment will contain only the sperm nucleus. Both fragments are capable of development. Both were watched continuously under the microscope during their significant period of development.

It is obvious that if there has been a complete segregation of organ-forming substances in the unfertilized egg, a fragment containing only material from the animal half of the egg should be able to form no digestive tract and no skeleton (the larval skeleton being formed by the mesenchyme cells, which in turn are derived from the micromeres); and that a fragment of the vegetal half containing only potential endoderm and mesenchyme should be without ectoderm enough for a body covering. Similarly, if all the potential mesenchyme has been segregated in the region of the vegetal pole, the large fragment remaining after the removal of the vegetal polar region should give a larva in which no mesenchyme and therefore no skeleton would be formed.

Further, if there has been a complete segregation of organ-forming substances in the unfertilized egg and this material has a radially symmetrical arrangement around the axis of the egg, section through the poles along the axis should give two fragments that would form the same number of micromeres on each piece; four on each, if each cleaved as a whole egg; two on each, if each cleaved as a half egg. If the cleavage of the fragments were that of proportionate parts of the whole, the number of micromeres on each piece should vary with the degree of inclination of the plane of section to the axis of the egg.

The results of the experiments proved conclusively that neither size of fragment nor the region of the surface involved is of influence on the formation of primary mesenchyme. A fragment of about one twentieth the volume of the entire egg, taken from near the animal pole, the region farthest from that in which the localized micromere-forming substance may be supposed to lie, may give rise to a normal blastula with mesenchyme. The discovery of the fact that the formation of primary mesenchyme is not dependent on the formation of micromeres is merely incidental. Fragments that during their cleavage give rise to no micromeres, or to one or to two or to three or to four, may all give rise to larvae with mesenchyme. The important result of the experiments is the proof that prior to fertilization there has not been a complete segregation of either mesenchyme-forming or endoderm-forming substance and that a mesenchyme-endoderm-forming substance has a uniform distribution throughout about nineteen twentieths of the egg. The animal polar cap seems to contain only ectoderm-forming material.

The results do not cast doubt in any way on the belief that the material from which the mesenchyme is formed is ordinarily cut off in micromeres at the fourth cleavage. They do show that, after the removal of the region normally giving rise to micromeres, the cytoplasmic tradition may be carried on, and out of its undifferentiated store new micromeres developed to replace the material lost. What is of more importance is the fact that even though no micromeres are formed, mesenchyme cells may be produced, and a perfect larva formed. As a matter of fact, there is nothing new in this conclusion. Driesch and Zoja both came to the same result thirty years ago. Zoja's practically forgotten observation is of especial significance for the reason that the micromeres of the cleaving egg were removed with a needle from the sixteen-

cell stage, all four being isolated in such a way that there was no doubt of the observation. The remaining macromeres and mesomeres produced a perfect pluteus.

The statements made thus far indicate the totipotency or equipotentiality of different parts of the egg. In order that we should form no incorrect conclusions it is desirable that we should note that a certain volume of material is necessary for complete development.

Fragments of
1/75 to 1/50 the volume of the egg did not accept fertilization;
1/50 to 1/35 became fertilized, but did not cleave regularly;
1/31 to 1/24 cleaved regularly;
1/21 to 1/17 became blastulae with mesenchyme;
1/11 to 1/10 became gastrulae, and
1/4.4 = (5/22) became normal plutei

In other words, no fragments smaller than one fourth the volume of the egg reached the characteristic sea-urchin larval stage.

We may now go further and make specific application of our general statements concerning polarity and symmetry to other results of the series of experiments.

Very early in the work it became evident that in most of our fragments the first two planes of cleavage were at right angles to the plane of section and that the micromeres were formed on the surface of section at the intersection of these two planes. The place at which the micromeres appear becomes the posterior end of the blastula. It is therefore evident that in some of the fragments there has been a change in polarity. Following horizontal section there is no change in polarity in the animal fragment. In the vegetal fragment it has been reversed, shifted through 180°; in the fragments obtained by vertical section it has been shifted through 90°. A new axis has been established. No explanation of this phenomenon has been reached.

Concerning symmetry. In large animal fragments obtained by diagonal section the asymmetrical cleavage of the fragment suggests the persistence of an established plane of symmetry. The statement that the results suggest, but do not demonstrate, a bilaterally symmetrical organization of the egg is deliberately conservative. It is known that the eggs of many forms are bilaterally symmetrical. For the sea-urchin egg, however, the idea that symmetry is determined at the time of entrance of the spermatozoon has been generally accepted. That this may not be the full truth is suggested by the observations mentioned above and by the fact that sea-urchin eggs activated by reagents causing parthenogenesis also give rise to bilaterally symmetrical larvae.

Concerning the organization of the egg of the sea-urchin *Lytechinus* it may be said that the evidence shows that the egg has polarity and that the animal polar cap contains only potential ectoderm. The evidence suggests strongly a bilaterally symmetrical rather than a radially symmetrical organization. It also shows that such fundamental characters as polarity and symmetry may be established epigenetically in egg fragments.

The egg is a living cell in which one of the characteristic attributes of living cells, division, has been suspended. It has, so to speak, been withdrawn from an active existence. It remains in a state of inactivity until it is activated, in the normal course of events, by the entrance of a spermatozoon. The results of the entrance of the spermatozoon are two—the activation of the egg to development and the modification of the course of development in such a way that biparental inheritance becomes evident. The successful development of the Roux-Nageli-Weismann theory of the idioplasm has been possible because of the visibility of the phenomena of mitotic cell division. The intensive

study of the nucleus has been possible. No one has consciously lost sight of the fact that in the activities of living substance we are dealing with nuclear enzymes and a cytoplasmic substrate. Each is necessary to the other. The nucleus can not act unless it has something on which to act. The cytoplasm can not develop unless it is acted upon.

Conklin, in 1915, stated his conclusion that "the egg cytoplasm fixes the general type of development and the sperm and egg nuclei supply only the details."

A little later Loeb in "The Organism as a Whole" wrote,

> The most important fact which we gather from these data is that the cytoplasm of the unfertilized egg may be considered as the embryo in the rough and that the nucleus has apparently nothing to do with this predetermination. This must raise the question whether it might not be possible that the cytoplasm of the egg is the carrier of the genus or even species heredity while the Mendelian heredity which is determined by the nucleus adds only the finer details to the rough block.

In 1912 at Montego Bay in Jamaica I had the opportunity of studying the development of the sea-urchin *Cidaris*. In its early development this primitive sea-urchin is unlike any other echinoid that has been studied. The manner of formation of its mesenchyme resembles that described by Seeliger for the crinoid *Antedon* rather than that which we associate with the echinoids. The formation of mesenchyme occurs after gastrulation has begun, the mesenchyme cells arising from the inner end of the archenteron.

For a study of the early effects of hybridization this egg offered all the advantages of the crinoid egg. Two cross fertilizations were made, one with *Lytechinus*, the other with *Tripneustes*, both regular echinoids that form their mesenchyme early, *i.e.*, in the stage of the blastula. In both crosses the mesenchyme cells arose from the sides and around the base of the archenteron, close to the point of union of the archenteron with the wall of the gastrula. In point of time the appearance of the mesenchyme seemed slightly hastened, although not enough to warrant a general conclusion to that effect.

This result gave earlier visible evidence of the influence of the spermatozoon in the production of paternal characters than had previously been obtained. The reason for this lay wholly in the nature of the material. Material belonging to two visibly different systems of development was used.

Development of the hybrids proceeded regularly as long as it followed the general path of development taken by most echinoids. At the point of divergence of special from general, abnormalities appeared. An orderly series of developmental reactions had been disorganized by the introduction of foreign nuclear material. In 1923 in my report on this work I stated in conclusion,

> The normal development of the *Cidaris* egg is of a less specialized type than that of the eggs of the species whose sperms were used in the cross-activations. As long as the two courses of development lie parallel, we say that development is normal. When the point of divergence between the two paths is reached, characters appear which we call aberrant. Differentiation lies in a series of reactions between nucleus and cytoplasm. In attempting to superimpose a specialized on a non-specialized type of development we fail, because of our lack of ability to harmonize two disharmonious systems of development.
>
> The consideration of this material emphasizes again the fact that the thing inherited by offspring from parent is the capacity for development. What that development will be depends on the interactions between nucleus and cytoplasm and on adjustment to the environment. The cytoplasm is the material that is shaped during the series of reactions. It is because of the fact that the cytoplasm of the egg is the material basis of the body that Conklin's statement that the egg cytoplasm "fixes the general type of development" is true.

A few moments ago, in describing the appearance of the egg, I said, "One may distinguish between living substance

(protoplasm), included materials (deutoplasm) and transitional stages between these two, each being the end product of a reversible reaction." This is a bold statement and demands proof.

It has not been possible to treat living material in a manner similar to that in which an organic chemist may treat crudes. The nature of living material seems to render that impossible. The determination of the chemical nature of the formed components, inclusions, in the egg should not be an impossibility. During the past three years with the help of two collaborators, my colleagues Dr. M. S. Gardiner and Dr. D. E. Smith, as well as that of both graduate and advanced undergraduate students, I have been attempting to reach a rational interpretation of the nature of the bodies that may be seen included in the cytoplasm of various cells.

The research had its foundation in evidence of the effect of foreign nuclear material on the cytoplasm of cross-fertilized eggs. Its first development was along the lines of an effort to determine the way in which yolk is transformed to living substance. Its status at present is that of a microchemical and biochemical study of biological material.

The study divides itself naturally into three parts: first, the study of the tissues; second, the chemical analysis of the tissues, and third, the study of the substances separated from the tissues, the latter part of the work being checked, so far as possible, by a similar study of purified commercial products.

Having done these three things, the opportunity for the comparison of the stained tissues with the stained separated substances is open.

The plan would be simple and direct if it were not for two facts. In the first place, similarity of staining reaction does not necessarily indicate identity of substance. Most of the dyes used as biological stains are "indicators" only in a limited sense. In the second place, there is no means of demonstrating that the substances obtained from the tissues are those that were in the tissues when the necessary manipulations were begun.

Eggs and ovaries of the sea-urchin *Echinometra* have been studied with vital dyes and have been preserved (fixed) with reagents designed to preserve included substances. This material has then been sectioned and stained with the dyes that are of use in the demonstration of formed components in the cytoplasm. The use of sea-urchin material is merely incidental. The use of this particular sea-urchin was determined because of the abundance and unusual staining capacity of its inclusions.

Material from the same source was preserved and extracted in strong alcohol, analyzed chemically and studied further. Nothing has been washed out and thrown away. Thus far the work has dealt with the fats and to a limited extent with the carbohydrates. Nothing has been done with the proteid content. The ether-soluble portion of the original alcoholic extract has been separated into its fractions. At each stage of separation these fractions have been studied with vital dyes and have also been made into emulsions which have been fixed, stained and studied as though they were animal or plant tissue, or have been floated as films on the fixing fluid and subsequently stained and studied.

A single example will be sufficient as an illustration. One of the formed components of the cell is the Golgi body, composed of a substance that reduces metallic salts, the metal (silver, osmium, etc.) being deposited in the Golgi body. The Golgi substance may be seen in the form of blackened droplets or rods, in the form of a vacuole whose rim is either completely or interruptedly blackened, or in the form of a vacuole containing a deeply blackened net.

Upon treating the young germ cell, before the accumulation of inclusions has begun, with osmic acid, no blackening effect will be observed. Upon treating a similar, but older, cell with this reagent, a diffuse blackening may be seen. In an older oocyte fine blackened granules may be demonstrated; later, characteristic blackened batonettes, and finally the Golgi body with its blackened network will be evident.

Similar observations may be made with the aid of certain vital dyes; Nile blue sulphate, for example, gives especially significant results. It stains pure neutral fat red and fatty acids blue. During the past few weeks its use has given us very significant results in the study of amphibian blood corpuscles and in cells of tissue cultures.

The same type of observation on the extracted fats, both with vital stains and following the use of fixatives containing osmic acid, has been made.

Step by step the fractions in which the blackening by osmic acid is not persistent were eliminated down to the residue containing neutral fats, cholesterol and fatty acids. The neutral fats are blackened by osmic acid, but osmicated neutral fat is readily soluble in turpentine, while the osmicated Golgi substance is resistant to solution in turpentine. One fraction after another was eliminated as not being the cause of the persistent blackening. The cholesterol was eliminated.

Finally within the last few weeks, after the study of the saturated fatty acids, the unsaturated fatty acids have been studied. These blacken almost instantaneously with osmic acid. They resist extraction or solution in turpentine. With them every stage of Golgi body that has been demonstrated in fixed tissue can be duplicated.

These are facts that have great significance when applied to any cell in which a process of storage or of secretion is taking place. (The Golgi body is characteristic of such cells.)

The growing oocyte is not an isolated, independent cell. It is part of the body whether attached to the ovarian wall or floating in cœlomic liquid. Materials for its growth are supplied to it from the surrounding medium.

The point to be made will be clearer if we digress for a moment and consider the processes of digestion and absorption of fats in the body. During digestion, hydrolysis of fats into glycerine and fatty acids occurs. These are absorbed separately and recombined in the cells of the villi of the intestine to form fat, the ester or salt of fatty acid and glycerine. The histological evidence just presented to you indicates that the same process is taking place in the growing oocyte.

We know that the particles actively concerned in the vital processes of the cell are of a size beyond the limits of observation with the microscope. Products of their activity become visible only when the granules of product come above this horizon.

The whole picture of accumulation of osmic blackened substances in the growing egg is that of synthesis of fats. The diffuse cloud, the formation of fine granules, of chains of granules and finally of larger droplets are the visible expression of one series of vital processes, processes that may be correlated by direct observation, with the interaction of nucleus and cytoplasm.

The same type of evidence that has been given for the Golgi substance may be given for the phospholipins, whose visible expression is in the chondriosomes or mitochondria. Both Golgi substance and chondriosomes may be looked upon as transitional between inert and living substance.

These are facts. The method employed in their demonstration has been direct. There seems to be one logical conclusion.

THE NEW FERTILIZERS

By Dr. W. S. LANDIS

The Origin of Agriculture

True civilization began with the discovery that when certain varieties of seed, known to possess food value, were sown upon upturned soil, they reproduced themselves multifold. Such a food supply, and of considerable reliance, required a more or less fixed abode and gave opportunity for thought and study which are the basis of our civilization.

Throughout the Stone Age man was a hunter and savage, gaining his food solely from the chase. These first truly human beings hunted the wild grasslands in packs, the men and women sharing alike in the pursuit and its products. The cares of maternity at times caused the women to drop out of the hunting party for short intervals, later rejoining it again and with their offspring if the latter survived. By degrees more and more attention was paid to the raising of the young, and the detachment from the hunting party was for longer intervals. The women established at least temporary homes to which the hunters would return at intervals with their catch.

This development in turn restricted the active hunting area, and with increase of population of the crude settlement, due in part to proportionately greater survival of the young, game naturally became scarcer and the chase sterner. The women gave more and more time to the household and the children, and the chase called for more and more skill and endurance. The female eventually dropped entirely out of the chase and left food supply to the male.

Were the chase only moderately successful, or the male kept away too long, the generally scanty stores of food would be exhausted and the women and children face starvation. Thus necessity probably drove the women to supplement their meat diet with nuts and berries, and, finally, in extreme desperation, with seeds and roots collected near the habitation. Our first vegetarians were undoubtedly the women and children.

Such periods of great stress must finally have forced the eating of edible seeds of the wild grasses and the primitive grains on the male. His meat diet probably persisted longer than with the female. It is possible that climatic changes were responsible for some of the great rainfall and of subnormal temperatures.

A further stage of development and at a much later date, characterized by the domestication of animals, furnished a more assured meat supply, but apparently did not alter appreciably the earlier acquired vegetarian habits. These pastoral peoples, following their flocks to the fresh pasturages, moved but slowly. The wild grasses and primitive grains still furnished a portion of the food supply. Coincident with this pastoral development, but not necessarily parallel, we find our first evidence of agronomy. There are reasons for believing that agronomy was practiced before animal husbandry in Mesopotamia, but the reverse is indicated in other centers of early development of the human race.

We can only theorize as to the actual beginnings of grain growing. Settlements of some permanence must have been customary, for a very considerable part of the year is required for the reproduction of a seed of the type of the wild grains, as emmer, wild rye, millet, etc. It is not unlikely that an accidental

spillage of seeds being carried into the more permanent home showed the way. More plausible is the explanation that the wives decorated the graves of their deceased husbands with food and flowers, and seeds among the food-stuffs dropping on the newly upturned soil covering the grave sprouted and grew luxuriously. Bearing out this latter theory is the practice repeatedly discovered in various parts of the world of finding the early grain patches around graves. Later a corpse was always buried in the grain field, usually in a corner. If such corpse was not conveniently at hand at seeding time, a victim was sacrificed for the purpose. With the progress of civilization an animal carcass was found to be quite as efficacious, and the ritual of animal sacrifice at planting time persisted for a long, long time.

Exact dates can not, of course, be established for such beginnings. It has been established with reasonable exactitude that grain was grown in Egypt before 4000 B. C., and in Mesopotamia still earlier, certainly before 5000 B. C.

The place that the woman played in this development has been recognized from the earliest times. We need but turn to our mythology for a long list of goddesses of agriculture, of the harvest, etc.; from Asia Minor, Agdistes, Cybele and Dindymene; from Egypt, Nysa and Isis; from Greece, Rhea and Demeter; from Rome, Flora, Ceres, Ops. There were no males so commemorated.

Fertilizers and Manures

It seems a long stretch of the imagination to look upon the early planting on and around the graves as a primitive attempt at improvement of yield through plant feeding, yet the practice of human and animal sacrifice may have had behind it such a basis.

To-day it is the most common knowledge that seeds reproduce themselves when planted in cultivated soil. We learn quite early in life that the plant draws food from the soil, and the soil soon becomes exhausted if such food elements are not replaced. Around this has grown our practice of manuring or fertilization. Let us for a moment get a clear understanding of these terms. The word "manure" is the older. It once had a much wider significance than it possesses to-day. Originally it meant "to work by hand," and much later acquired the more restricted meaning of "a material or process for the betterment of the soil." It was not until the seventeenth or eighteenth century that further limitation of meaning took place, and its use became generally restricted to materials used in such betterment of soils. At first even in its most narrow of the above senses it included chalk, gypsum and lime as well as what we now call "farmyard manures." We now apply it to this last-named material alone.

The term "fertilizer" is of comparatively recent origin. In general it is applied to materials which were presumed to feed the plant directly, in contradistinction to the "manure" which only indirectly fed it. Nitrates, ammonia salts, phosphates and potash salts were believed to be better classed under this newer term "fertilizer." But the end of such reclassification is not yet in sight, for within the past year the manufacturers of the common chemical or commercial fertilizers have objected to the use of the term "fertilizer" for their products and are advocating instead "plant foods."

On the subject of agronomy, which includes that branch of agriculture devoted to the growing of the crops and in particular grains, fruits and vegetables, we still have a great deal to learn of the fundamental and underlying facts of plant feeding. We know that seeds when planted upon certain types of soils

will under favorable climatic conditions reproduce themselves many fold. We also know that when this same operation is repeated a number of times on the same plot of ground the successive yields become less and less and finally seem to reach a certain fairly definitely fixed minimum of return. We can improve the return by using better seeds and there has been marked progress made in seed development. By rotation of crops, that is, the successive planting of seeds of different families, the decrease of productivity can be halted to a marked extent. By the use of addition agents to the soil crop yields can be maintained or even improved. Knowledge of the use of such addition agents goes back probably to the very early days of agriculture. The use of animal excrements dates before the dawn of recorded history. The earliest writings of the Romans mention the value of dung, of which Virgil sang. Varro and Columella, the earliest agricultural writers, mentioned not only the use of farm manure, but of marl, and spoke of the effect of green manure upon the succeeding wheat crop.

There seems to have been a gap left in the literature of fertilization during the Dark Ages, and it was not until the Renaissance that writings upon agriculture became common. There was no mystery in the use of farmyard manure, marl, lime and ashes for promoting crop growth. Just when the Indians of New England learned to place the fish in the corn hill is not recorded. Undoubtedly all these early fertilizers and manures were accidental discoveries.

The first real scientific basis of our modern practice dates back to the great chemist Liebig, approximately ninety years ago. Liebig probably originated very little, but he reduced the great mass of experience of his predecessors to an exact quantitative basis. His careful analysis of the constitution of the growing plant, showing that 95 per cent. of the dry matter of the plant was derived from the atmosphere and only 2 or 3 per cent. was drawn from the mineral constituents of the soil, threw an entirely new light upon plant feeding. His early work was followed immediately by comprehensive experimental work, the most noted of the early beginnings being that of Sir Joseph Bennett Lawes, who began systematic experiments on the family estate at Rothamsted, which estate is now our most celebrated agricultural experiment station.

What we now consider as most typical of our fertilizer materials did not, however, originate with Liebig. As early as 1653 English publications showed the value of rags, wool, bones, horn and wood ashes. A few years later blood, hair, feathers, hoofs, skin, fish, malt were added. Twenty-five years later the value of niter or saltpeter as a fertilizer material was recorded. Fifty years later soot and wood ashes, oil cake and grain dust were added to the list. It was during the nineteenth century and probably contemporaneous with Liebig's work that the greatest developments took place. Chile nitrate and Peruvian guano were imported into Europe for agricultural purposes. Practically at the same time, 1842, the first superphosphate patents were taken out, and a year or two later superphosphates began to appear on the market. The potash salts were added to the list in 1860 with the opening up of the Stassfurt beds. At about the time that nitrate first came into the European market, sulphate of ammonia also appeared in quantity and was tried in agriculture.

Liebig's analytical work confirmed the presence of nitrogen, phosphate and potash in appreciable quantity in the living plant. The early fertilizers and in fact most of those compounded even to-day base their principal value upon these three ingredients. Our knowledge,

however, of the constitution of the plant shows that it contains practically every known element, some, it is true, in extremely minute quantity. The soil itself is an extremely complex material. Most of the elements found in the plant are derived from it, for the living plant draws little besides carbon and nitrogen from the atmosphere and very little of the latter directly.

Plant Foods and Plant Stimulants

It is probably unwise to take the broad view-point that a fertilizer is any material which is added to the soil to increase plant growth and crop yield. Such definition is too comprehensive. An increase of yield may be due to one or more of several factors. Growth may be promoted by feeding, in which case our fertilizer should contain the necessary elements which, when absorbed by the plant, promote growth. Nitrogen, potash, phosphate, manganese, zinc, vanadium, titanium and a host of other elements would come under this class.

We recognize that bacterial action plays an important part in rendering soil constituents available for absorption and conversion by the plant. Bacteria are rather particular about the kind and conditions of their surroundings. If we can promote the development of bacteria which in turn converts our soil constituents into more available food, we usually obtain response in growth. We may, therefore, add to the soil conditioners such as lime, and bacterial foods such as manures and organic matter which promote the development of these colonies of valuable assistants. Such materials would not necessarily come under the class of plant foods but rather as conditioning agents or bacterial foods.

Of recent years we recognize still a third method of increasing plant growth, which we class as seed stimulation. We are not so clear as to the function of this group of materials, but apparently they act in much the same way as the tonic which the physician gives us when we are not quite up to par. In general the seed itself is treated with these reagents, resulting in a quicker sprouting and more elaborate development of root structure and a material increase in growth and yield. Here again we have crop improvement without the addition of a plant food or soil-conditioning agent. It is more a stimulating effect forcing the sprout to develop an abnormal root structure capable of picking up from the soil a correspondingly increased quantity of latent plant food. In view of the complexity of these three very widely different phenomena I am inclined toward the present tendency to drop the word "fertilizer" as applied to our commercial product containing nitrogen, potash and phosphate and use instead the more descriptive term "plant food."

Present-day Plant Foods

The practice of preparing and using artificial fertilizers differs in various parts of the world, just as general agricultural practice differs. In some localities the individual materials which the farmer had determined most suitable to his needs are purchased and applied singly to the soil. This practice received its highest development in Europe and persisted up to recently, at present showing a tendency to a change to the practice of using a compounded or mixed fertilizer. In the United States our practice has been the reverse and the plant foods have been assembled and mixed at a centralized factory, and one application is made of the composite material. Even here there has been a tendency to buy the ingredients and assemble them on the farm, but it is probable that we will see a return to the older practice with the advent of the newer fertilizers. The choice is largely a question of availability which in most cases means cost of labor.

Liebig's work demonstrated that nitrogen, phosphorus and potassium were the most important constituents of the plant structure that of necessity had to be supplied to the ordinary soil to maintain the crop yield. Soda, lime and silica, while important constituents, are present in sufficient quantity in the usual soil to present no problem of exhaustion. In view of the very wide variation of cultivated soils throughout the world it must be remembered that there are always some exceptions to any such general statement. Upon this foundation our fertilizer practice arose. Such materials as nitrate of soda and sulphate of ammonia, being available in quantity, formed the nitrogenous portion; mineral phosphates found in various parts of the world by suitable chemical treatment could be rendered soluble, and the processing of these materials took care of the phosphorus requirements; the discovery of the potash salts in Germany and later in France, Poland and Spain formed the basis of the potash constituent. In addition there have been vast quantities of otherwise wasted products, such as refuse from the slaughter house, oil cakes and meals from the oil factories, hair, wool and leather scrap from various sources, all of which contain valuable plant foods in more or less available form or if unavailable can be simply processed to make them acceptable fertilizer materials. In the case of certain slaughter-house products and oil meal cakes, these products which years ago found their only outlet in the fertilizer industry have now found application as stock foods, and vast quantities have been diverted from the fertilizer to the feeding industry.

The fertilizer industry has in consequence come to depend more and more upon chemical products for its raw materials. The natural nitrate of soda and the by-product sulphate of ammonia, to which have been added of more recent years various synthetic nitrogen chemical products, such as cyanamid, nitrate of lime, urea and ammonium phosphates, now form the bulk of our nitrogenous ingredient. There is little chance of return to the waste organics, and with better education of our farmers the little still used will further decrease.

The phosphate industry still relies largely upon the natural deposits of phosphate rock for its raw material; processed with sulphuric acid this has appeared upon the world markets as superphosphate. Processed with phosphoric acid a more concentrated form of soluble phosphate has been produced, but up to the present the quantity of the latter used is only a small fraction of the former. Within quite recent years the raw phosphate rock has been used for the production of phosphoric acid either by chemical or electrothermal processes, and this phosphoric acid has been treated with ammonia or potash to form the corresponding phosphate salt.

There has been little or no change in the potash industry which since its inception has turned out various grades of chloride of potash or sulphate of potash.

The American Mixed Fertilizer

Here in America, where labor costs are high and extensive farming is practiced, it has been customary to supply to the farmer the three important plant foods in a compounded or mixed form. The processing may be simple or complex, depending upon the raw materials used in the preparation of these fertilizers. In its simplest form it consists of a mere mechanical mixing of various purchased ingredients to meet a definite formula. In its more complex form less available nitrogenous materials undergo a chemical processing, usually in the presence of phosphate rock, forming a semi-manufactured material. This in turn is mechanically mixed with other raw materials to form the complete fertilizer.

These American mixed fertilizers contained as little as 10 per cent. of the plant foods, ammonia, phosphoric anhydride and potassium oxide, which are the chemical names for the more common designations, ammonia, phosphoric acid and potash. Most of such low-grade products have been legislated out of existence within recent years and very few fertilizers that appear on the American market contain less than 12 per cent. of the plant foods, ammonia, phosphoric acid and potash. The tendency to-day is to produce materials running from 14 to 16 per cent. of these ingredients in the bulk of the fertilizers turned out.

Quite recently there has appeared on the market the so-called double strength or double formula fertilizers containing from 20 to 30 per cent. of plant foods.

This American practice of mixing the important plant foods together in a factory and selling the resultant mixture to the farmer had long been frowned upon by the European agriculturist. The basis of his criticism was that this system was forcing the farmer to purchase materials which he really might not require, and that a better principle was to analyze the soil, determining the lacking plant foods, and then supply only such deficiencies. No objection can be taken to the theory behind such a procedure, but in practice it did not always work out successfully. The taking of accurate soil samples is a complicated procedure. The analysis is long and tedious. The interpretation of results is very difficult. A high-pressure salesman falling upon the farmer at purchase time forced the sale of his single ingredient, and for one of several reasons the farmer usually bought a most unbalanced fertilizer. Now the plant is not able to substitute to an unlimited extent one plant food for another. If a surplus of nitrogen is present a plant thrives only to the extent of the most deficient of the other important foods, as, for example, phosphate or potash. It avails very little to supply large quantities of nitrogen without adequate amounts of phosphate and potash. At the close of the war there were in existence in Europe enormous factories built during the war for the supply of nitrogen for munitions. At the close of the war these plants turned to the production of fertilizer nitrogen salts and forced their product upon the home markets with the result that there was only a temporary increase in food production, and crop yields gradually dropped off in spite of the continued enormous consumption of nitrogen. A comprehensive study of the situation showed the trouble to lie largely in deficiency of one or more of the other plant foods, and a complete change of manufacturing program was embarked upon with the object of producing à complete fertilizer containing the three plant foods balanced at least to the extent of insuring a fair crop yield. In other words Europe today is adopting at least in principle the old established American practice of furnishing the farmer a mixture of three important plant foods in proportions to insure at least fair crop returns.

The New Fertilizers

As mentioned above the fertilizer industry, more particularly in this country, developed first around a practice of using a great mass of waste materials. Most of such materials are of comparatively low analysis, and when they contained any quantity of nitrogen, such as the better grades of cotton-seed meal, animal tankage, fish scrap and the like, they found their way into the feeding industry, leaving only the lowest grades for fertilizer. As a result of this use of very low grade, or more properly speaking low analysis materials, the mixed fertilizer produced contained a comparatively small amount of plant food. Twenty years ago we began to extract nitrogen from the atmosphere and con-

vert it into chemical products and to-day more of such so-called synthetic nitrogen is produced than comes from the by-product coke-oven and the nitrate fields of Chile. Most of the synthetic nitrogenous compounds produced are of comparatively high analysis. The processes of production themselves are rather flexible, enabling one to obtain the chemically combined nitrogen in several concentrated forms. There is a widely diversified field into which the primary products of these fixation processes can be diverted. It has, therefore, appeared logical to maintain the concentrated characteristics of these new synthetic compounds and with them to produce much more concentrated fertilizer. As a consequence there are on the markets to-day complete fertilizers containing 40 per cent. and upwards of the three plant foods. The whole fertilizer world is actively engaged in research along these lines, and we may expect in the future to find still further new combinations lending themselves to the production of these concentrated or high analysis products. In general these materials are of the types of ammonium nitrate, ammonium phosphate, potassium phosphate, potassium nitrate and like combinations. The underlying principle is to eliminate so far as possible the non-plant food ingredients.

Distribution Problems

The distribution of fertilizer is quite a problem. The various products formerly used came from widely different sources. They were assembled in mixing plants, bagged, tagged and guaranteed as to content and then transported to the farm centers. Further transport to the farms was then required and finally distribution in the fields. The costs of assembling, bagging and transportation to the farm centers in many cases equaled the wholesale value of the plant foods contained, so that the practice was not particularly economical in the case of the low-grade materials. The actual costs of field distribution alone formed a very appreciable item where the material contained only 10 or 15 per cent. of plant foods. With the advent of the higher grade materials analyzing three or four times as concentrated as the older types these distribution costs could be cut materially. From the economical standpoint there is, therefore, a marked advantage in increasing concentration of the fertilizers.

The older fertilizers made up very largely of a slightly soluble phosphate mixed with the insoluble organic nitrogenous materials and with only a modest quantity of soluble salts offered no great problem in field application. The minimum of care and the use of the crudest equipment enabled the farmer to avoid damage or burn. The new high analysis fertilizers, however, are essentially water-soluble materials. Their application, if injury to the growing plant is to be prevented, requires more care and in particular a more thorough incorporation with the soil before or during seeding. They must be located more carefully with respect to the seed. The economical quantities used are much smaller than with the low analysis materials, and require equipment capable of fine adjustment. None of these problems, however, is insurmountable, and my staff has planted hundreds of plots over the past three years with fertilizers containing as much as 60 per cent. of plant food and all in water-soluble form, using the better standard grades of available farm equipment without difficulty or damage.

There is still another phase of the new fertilizer situation which is now commanding our best attention. I mentioned earlier the fact that careful analysis of the plant showed it to contain a very wide variety of elements, and it is believed that most of these play a vital

part in the growing plant. In the old days most of the waste products used were of plant or animal origin and contained many of these essential elements. Phosphate rock itself is a most complex material and in the process of manufacturing superphosphate the whole of the rock appeared in the superphosphate, so that fertilizers compounded of these materials contained most of these vital elements even though in extremely minute quantity. Many of the newer fertilizers are crystallized products, that is, chemical products crystallized from solution and in the process of crystallization purified or freed from contaminating elements. The disappearance of the organic wastes from our fertilizer materials leaves out another source of supply of some of these rarer elements. In consequence the agronomist is now faced with a new problem and must be on the eternal lookout for elemental deficiencies of more or less unsuspected nature. I have in mind the case of the Florida soil which refused to produce tomatoes until a small quantity of manganese was added. I also have in mind two other cases where zinc in one and titanium in the other were necessary to successful agriculture. I believe, therefore, that we are opening up a new field of investigation of the influences of new elements, which influence has not been felt on account of the older fertilizer practice, but which may show up in a substantial manner in the case of some of the new fertilizers such as are being produced in Europe. It is a subject to which some of us are paying the closest attention.

Summary

Summing up, the future fertilizers will be much more concentrated in the three common plant foods than even past history would lead one to suppose. The older organics of animal or vegetable origin will disappear to still greater extent and will be replaced by newer synthetic salts mostly of inorganic nature. There is no particular advantage from the agricultural standpoint in these organics and the newer products will produce equally good or better results. Education of the farmer in the use of the newer synthetic products will decrease the demand for the organics to that point where they sell at an equally competitive price.

There will be a material change in the character of the inorganic fertilizer materials, and those showing tendency to deflocculate soils, others showing tendency to leave harmful residues in the soil and those of inferior physical characteristics will disappear and be replaced by greatly improved combinations. Many new elements will be added to the list of essential plant foods. Process limitations existent to-day will disappear in so far as they eliminate essential plant foods, and the science of compounding will be greatly elaborated as we require better knowledge of plant requirements and soil deficiencies.

The dream of the concentrated synthetic foods of the human race will be realized first indirectly through supplying a similar material to the soil and letting nature carry on an intermediate transformation.

SCIENCE AND EDUCATION

By Professor WILLIAM D. TAIT

McGILL UNIVERSITY

"As civilization advances poetry necessarily declines." Leaving aside the literary significance of that statement, it must be admitted that when poetry was the *sole* expression of man in relation to his surroundings he was untutored, unlearned and uncivilized. As he advanced, when he came to know more about his place in the scheme of things, in a word, as he became more civilized, he found other and more exact means of expressing his relation to the world of nature. This refinement of expression is synonymous with scientific progress. Science then means a better and more exact knowledge of the world we meet with day by day. Mankind is no longer at the mercy of nature. Nature is now a servant, not a master.

Man's advance in civilization is thus to be measured in terms of the nicety of adjustment to his environment, or to put it otherwise, his efficiency in meeting his environment is the measure of his civilization, and the records of this advance are to be found in the annals of science. This increased efficiency can only come about by man's knowing more about the world in which he lives, no matter whether it be the so-called outer world of nature, his fellowman or even himself. Progress in civilization or towards civilization, if we admit such a thing, depending on efficiency and this efficiency depending on knowledge, the conclusion is that civilization depends on knowledge. However, it is a mere platitude to say that progress depends upon knowledge. When we speak of knowledge in this context we mean scientific knowledge, the sort of knowledge which consists of facts grouped in what are known as scientific laws which are exact statements of facts, not general hearsay or opinion, or knowledge in the vague sense, but exact, detailed and careful knowledge. These laws can be used for our advantage or disadvantage, and upon our wise use of them depends our progress.

The desire to be master of his environment led man to become a scientist and the beginning lay in magic. Doubtless this depended then, as it does now, on certain innate tendencies called instincts, and the two which probably play the greater part are curiosity and pugnacity. As long as myth, superstition and poetry were found sufficient and satisfactory, just so long was man at the mercy of his environment. All this changed as his curiosity and pugnacity bore fruit. At first, this inquiry was confined to the outer world, and thus one of the oldest sciences is physics, but the success there and the impetus thus gained has led science into all fields with the same productive and beneficial results to man and his problems of living. Much to the surprise, and contrary to the a priori speculation of some, including Kant, we have to-day a science of mental life which in general employs the same methods as the other and older sciences. The step of psychology has been very rapid because it found method and instrument ready to use and was thus relieved of much of the pioneer work which fell to the lot of the others, not the least of which was the overcoming of prejudices.

Simple as the statement may appear that science enables man efficiently and competently to meet his environment and

thus make progress as a civilized being, yet it has some profound and far-reaching consequences. It means, first of all, that we are, as yet, only at the beginnings of science, and it means, too, that in the struggle for existence, which struggle is unending, the individual or nation or race which knows most about the conditions to be met and the way to meet them, in other words, the one with the best scientific equipment, is the one which will survive. That inexorable law of selection still holds, but in a very intricate, refined and subtle way. Ignorance spells non-adaptability, failure, defeat and submergence. In yet another sense, it signifies that the days of the gentleman scholar, the amateur scientist, the man of general culture, are numbered, because the equipment which these individuals represent is insufficient and therefore inefficient even at the present time and will be increasingly so in the future. It signifies, further, that the periods to come in world history will be periods of specialized thinking, which may mean, in a way, the sacrifice of the individual. Yet it is only by such rigid scientific procedure in all the affairs of life that a people can become and remain efficient and cultured. A nation whose educational system is founded upon merely individual attainment, where each one thinks he knows something of everything and not much of anything, is doomed in a modern and ultra-modern environment. We must stand for corporate and national efficiency, and to do this well and thoroughly we require an intricate and accurate knowledge of our world which only scientific specialists can give. Hence we must have specialists in chemistry, physics, physiology, biology and in all the various aspects of life.

Some, of course, will see in such a thorough application of science to the affairs of life a merely utilitarian attitude, as if that were the deepest curse which could be uttered. For those who have a wider outlook and greater vision, who see life in its deeper parts, who see truth and beauty in all things, the word utilitarian has no such connotation. Mill did not use the word in this bad sense, and if his critics have been so narrow-minded as to do so, then the odium rests with them. The word should mean, and does mean, any truth which will help us to live and live better. It means the best in order to survive, and that means efficiency of reaction in the widest and best sense. In fact, the terms utilitarian, efficient, good and true are not very far asunder when looked at from the point of view of service to humanity. What other test have we for our ideals? Name it, reduce it to its lowest terms, and you have efficiency. It is the capacity of doing the right thing at the right time, and doing it well.

There are those, too, who think that science and culture are opposed, who are convinced that all culture and humanity are contained in the writings of Greece and Rome, or in works based on them. Such people fail to see that the scientific position not only includes the so-called classical, but is its foundation. Without science and philosophy (for philosophy is the mother of science) the world would be without many of the classics. When we read our Democritus or Plato or Aristotle we are reading the scientific speculations of their age. This goes by the name of culture with those who refuse to extend the same courtesy to the speculations and researches of modern science. Future ages will do as we do with the past—they will read our science and philosophy and the classicists of the day will call it culture. However, this is only one way of looking at the question. It is to be further remarked that with some of this mode of thought, culture is a much-abused word

for a rough smattering of scientific and literary information on many things, and a real, useful knowledge of few, if any. These people are accustomed to pride themselves on their breadth of view and their wide outlook, but it is a breadth based upon superficiality. Nothing is more deceptive than such a position. No man is really so narrow as the man thus beguiled and lulled into the belief that he is of some value. It is the specialist who has the broad outlook, the deep insight into nature, who can give a reason for his open mind and who has knowledge and fact to support his point of view. (Even archeological research is becoming more and more dependent upon science in the narrow meaning of the term science.) From this type we are belabored about the futility of scientific research. This criticism is not new, for the modern dilettante in culture copies it from the Greek poets whom Plato anathematized. One of their favorite witticisms is to compare such research (here they are again not original) to the waste of energy, as they think, in estimating the height of a flea jump. The answer to an attempt to laugh at science is to say that the point has been missed, for modern scientific work is infinitely more detailed and complicated than a flea or his jump. It is just this exact sort of thinking that has raised man to where he is, and has made of him the controller instead of being the controlled. No race or nation which relies upon amateur scholarship, which looks down on the methodical searcher in the "mud" of facts, by his results upsetting many a fond tradition; no race which stands for general scholarship to the exclusion of special scholarship, can hope to win in the struggle for survival either intellectually or politically. It does not require much wisdom to draw the conclusion that political supremacy will be a consequence of intellectual supremacy. Past supremacy was due to mere physical force, but future supremacy will depend upon brain force. Our existence then depends upon our education. This increased predominance of intellect will hold true, no matter whether it is applied to the manufacture of explosives or to preparing an argument for the League of Nations. There was a bygone age when the rough and ready could win, when one man could know enough of all matters to be expert in them all; but that is past, and it is for us to realize this, that we may equip ourselves the more adequately for the conditions which we now face.

II

We have spoken of efficiency in general and the part that in general education should play, but the principle is not different when we come to discuss the particular case, when we speak of educational methods, when we inquire into the relation between teacher and pupil, as to how much the teacher or educationalist should know about the mind of the child, about economy in school-work, the means to get the best work with the least expenditure of time and energy. All of this is vitally important because the foundation of a nation's greatness lies in her schools—especially the primary schools. Thus it is right and our moral duty to make sure that the best and proper methods are used. As scientists we should insist at the very outset that common-sense methods, custom, tradition, speculation, superstition, mysticism and theory should give way to scientific method.

Now all the various sciences deal with some aspect of experience. Physics treats of one aspect, chemistry of another, psychology of another, and so on. They differ more as regards point of view than anything else. More particularly, physics in the large deals with what is usually and perhaps erroneously called the outer world, while psychology deals with what is usually and perhaps erroneously called the inner world or

mental life or the world of personal experience. This distinction is not an absolute one, for every experience of the outer world is at the same time an inner experience. The same fact may, therefore, be a subject of investigation for both physicist and psychologist. Psychology, then, is a study of experience from a particular angle or point of view.

There was a time when psychology, or what was then called psychology, speculated about mental life, but to-day the psychologist is coming to rely more and ever more upon experiment, or controlled observation. What is not the result of experiment is to be considered as in the doubtful class or category. It is now by experiment that we study sensation, perception, memory, association, emotion, feeling, volition. According to experiment we study differences between individuals of the same group, or different groups, compare the adult with the child and find out significant differences which should be an aid in educational method. By experiment, we ascertain how children differ with regard to the various mental processes and in intelligence. We find, for example, that those who learn quickly learn best, that the child has not the same capacity of forming abstract ideas as the adult—which should persuade us to leave science and mathematics and perhaps some aspects of history till the university age. We find that children have a good memory for isolated impressions, such as words, which would indicate that language should be studied in the early years. We are also impressed by the fact that English composition can be taught just as well by writing about the history or geography of a place as by paraphrasing some idiotic story. In this way much time that is wasted might be utilized to good advantage. The same holds good with regard to the teaching of English grammar, which is best taught by not being taught at all. The failure of modern methods is here very apparent. By simple tests we can separate defective, retarded, normal and bright children, and thus provide a better opportunity to each class. Extensive studies have also been made on reading and writing which should be available to every qualified teacher. By experiment then we are potentially able to note the whole progress of mental life until it attains maturity, and we can even compare it with the animal mind in the same way. All of this can be done with exactitude, for the psychologist has at his disposal both instruments and methods. In short, we can find out the facts of mental life in place of speculating as to what they are or ought to be in the light of some preconceived theory or speculation.

This latter tendency has come to us through philosophy and has produced something of a misunderstanding and thus accounts for some lack of progress. In this case psychology is identified with philosophy. The philosopher is considered a psychologist. This has been productive of much confusion in educational procedure and method. Some of this might have been true a century ago, but not to-day, and it is becoming more apparent that those who continue to think so are behindhand in their thinking. To-day, psychology is one of the experimental sciences, while philosophy is not. The two studies require different method, different type of mind and different preparation. Psychology, like any other science, is an intensive study of a small part of experience, while philosophy is an outlook on the whole. Psychology is an application of the experimental method to mental life; philosophy is anything but that. Quite true is it that psychology was once a branch of philosophy, but so were the other sciences, and now psychology bears the same relation to the parent as do the others. The facts and laws ascertained or formulated will have the same value for philosophy

as those of the sister sciences, but such value will needs be estimated by the philosopher himself.

The result of this comparison between science and philosophy was, and is, that exactness, certainty, uniformity in the good sense, were at a discount. In place of this, the application of scientific exactness to educational method means that in place of speculation, tradition, custom, common sense and chance we shall possess certainty, progress and efficiency, for in proportion as we utilize the facts and laws as revealed by psychological research just in proportion will we be on safe and secure grounds. The mind, both of the adult and the child, must be investigated from the point of view of education, and we must be wary about taking the results of general psychology. In other words, we require an applied psychology just as we have an applied physics.

In some antiquated nooks one hears some murmurs about the return to the old discipline and the old methods. The main argument advanced is that the new ways are failures. True, mistakes have been made, but mainly in attempting to graft new ways to old, to pour new wine into old bottles. It is to be frankly admitted, in all fairness, that some of the so-called modern ways are just as flimsy and superficial as some of the old, by reason of the same speculative foundation. No one objects to the old discipline, and modern psychology upholds some of it, giving it a new and important meaning, but although we believe in discipline, we are not thereby committed to the crude old methods of obtaining that result.

Now it is not for the teacher to accumulate all the psychological material available, nor is it the duty of the psychologist to make breakfast food for the teacher. The responsibility for this lies with the educationalist, for this is his business and proper function. It is also his duty to investigate particular and special problems or suggest them to the psychologist. With other words, the educationalist is the clearing-house between the psychologist and the teacher, just as the engineer is the clearing-house between the physicist and the artisan.

There is another side to this problem, albeit a vanishing one. Just as some will object to science as a whole, so there will be objections to the application of psychology to education, because of the delusion of materialism in some minds that it may mean doing away with aims and ideals and purposes, that it will detract from the glory and dignity of man, that education will lose its halo, its sublimity and its idealism. Let it be answered that science does not presume to set up ideals (they are the result of social contacts), but it does presume to provide us with the best methods of attaining our ideals, however formulated. Without science, ideals are merely potential; with science, they become actual.

The age of non-science is past. When our teachers, our educationalists and our university leaders come to realize that educational method must be placed upon a firmer and more secure basis than that afforded by mere speculation and common sense, when they consider it their duty to investigate every problem connected with educational method by exact experimental methods, then we can say that the teacher, of whatever station, belongs to a profession worthy of the best. Until then all our vaporings about ideals are vain and useless. Experimental pedagogy is the pathway to ideals in educational method—there is no other. Science is thus the true altruism and the true humanity, because it works as no other way. "Ever not quite" must be the slogan of educational as of any truth. Test all your customs, for their working value is the measure of their truth. Experiment performs this test more accurately and quickly than chance observation and experience.

MAN AND HIS CLIMATIC ENVIRONMENT IN THE TROPICS[1]

By Professor ROBERT DeC. WARD
HARVARD UNIVERSITY

When the tropics are mentioned, most persons, I feel sure, picture to themselves a tropical island with waving palms, a white beach of coral sand, and the blue sea beyond; or a wonderful tropical night, with the moon shining in a clear sky and the soft breath of the trade wind rustling the leaves. Poetry and romance seem inevitably to be associated with the tropics. Such idyllic spots do exist, it is true, but they form only a small portion of the tropical zone as a whole and are actually far less typical than the vast grim deserts or the wide open spaces of the grasslands or the dark and gloomy forests.

Within the tropics, under the equatorial sun, and where there is abundance of moisture, animal and plant life reach their fullest development. Here are the lands which are most valuable to the white man because of the wealth of their tropical products. Here are the tropical "spheres of influence" or "colonies" which are among his most coveted possessions. It is in this belt that food is provided for man throughout the year without labor on his part; in which frost and drought need not be feared; where shelter and clothing are so easily secured, and often so unnecessary, that life becomes too easy. Nature does too much; there is little left for man to do. The simplicity of life, so far as providing food is concerned, has been emphasized by many writers. We are told that two days' work a week is often enough to enable a man to support a family, and that a month's labor will provide for a Malay more food than he can use in a year. Captain Cook put the case very emphatically when he said that a South Sea Islander who plants ten bread-fruit trees does as much towards providing food for his family as does a man in northern Europe who works throughout the year.

In a debilitating and enervating climate, without the necessity of work or the incentive to work, the will to develop either the man who inhabits the tropics or the resources of the tropics is generally lacking. Voluntary progress toward a higher civilization is not reasonably to be expected. The tropics must be developed under other auspices than their own. "Where nature lavishes food and winks at the neglect of clothing and shelter, there ignorance, superstition, physical prowess and sexual passion have an equal chance with intelligence, foresight, thought and self-control." There is no superfluous energy for the higher things of life. Thus it has come about that the natives of the tropics have the general reputation of being indolent and untrustworthy; of always being ready to put off until "to-morrow." Obviously, no such sweeping generalization is to be taken too literally, for the lower latitudes have produced men far from deficient in physical and intellectual power, and in those parts of the tropics where natural conditions are more severe, the natives are usually more industrious. But it is true that the energetic and enterprising races of the world have not developed under the easy conditions of life in the tropics. Edward Whymper's Swiss guide said of the natives of Ecuador, "it would be good for tropical peoples to

[1] Based on a lecture given at the Lowell Institute, Boston, Mass., December 6, 1928.

have a winter." Guyot put the case in this way:

> A nature too rich, too prodigal of her gifts, does not compel man to snatch from her his daily bread by his daily toil. A regular climate, the absence of a dormant season, render forethought of little use to him. Nothing invites him to that struggle of intelligence against nature which raises the forces of man to so high a pitch, but which would seem here to be hopeless. Thus he never dreams of resisting this all-powerful physical nature; he is conquered by her; he submits to the yoke, and becomes again the animal man—forgetful of his high moral destination.

"What possible means are there of inducing the inhabitants of the tropics to undertake steady and continuous work, if local conditions are such that from the mere bounty of nature all the ambitions of the people can be gratified without any considerable amount of labor?" In these words, Alleyne Ireland has well summed up the labor problem in the tropics. If the natives are, on the whole, disinclined to work of their own accord, then either slavery, which has long been repugnant to civilized man, or imported labor, becomes inevitable if the tropics are to be developed. With few exceptions, and those where the pressure of a large population necessitates labor, effective development has in the past been accomplished only where imported Chinese, Japanese or coolie labor under some form of contract has been employed. Negro slavery began in the West Indies, under early Spanish rule, and its perpetuation was certainly in part aided by climatic controls. When slavery was abolished, large numbers of planters in English colonies were ruined. In Java, Holland succeeded by obliging the natives to work.

With a large native class which is indolent, working intermittently for low wages, or which is bound under some form of contract, it follows that the native or imported laboring classes are separated by a wide gulf from the upper, employing class, which is usually essentially foreign and white. The latter class tends to become despotic; the former, to become servile. Marked social inequalities thus result, accentuated by the fact that the foreign-born white is usually debarred from hard labor in a hot tropical climate. White laborers are not likely to become dominant in the tropics for two reasons: first, because the climate is against them; and, second, because the native is already there, and his labor is cheaper. White men are not doing the hard daily labor of India or of Java or of the Philippines or even of Hawaii. They are directing it. Except as organizers and overseers, they can not, so far as experience has shown, take part in the hard work of production and development. Physical labor for the great majority of the white race has definite limits. "The climatic environment makes it difficult for the body to keep cool, and as muscular activities increase the heat output, it is inevitable that such exercise should be avoided as much as possible." It has been urged, and not without reason, that white residents in the tropics would do well to follow the natives' example of moving slowly and of being lazy, but obviously habits of listlessness and of postponement till the morrow are not conducive to the exploitation of the tropics, and it is for that purpose that the white race is there.

I myself believe that the future must seek the solution of the problem mainly in the introduction of labor-saving machinery of all kinds, built for and adapted to tropical climates and tropical products and largely run by skilled white mechanics and engineers.

The government of European possessions in the tropics has thus far been determined chiefly by three considerations: First, the general incapacity of the natives, through ignorance or lack of

interest, to govern themselves properly; second, the fact that the white residents are generally comparatively few in number and are only temporarily in the country, to make money and then to go home again; third, the marked class distinction already referred to. These generalizations must obviously not be carried too far. The white residents constitute a caste and naturally become the rulers, the home government retaining general control, often by force of arms. The native population, although largely in the majority, may have little or no voice in its own government. This is clearly not a democracy. It thus comes about that the tropics are governed largely from the temperate zone; the standards and ideals come from another land. And where governed under their own auspices, as independent republics, the success has not as a rule been great. Buckle first strongly emphasized the point that hot countries are conducive to despotism and cold countries to freedom and independence, and the control of climate over the form of government was discussed by the late Lord Bryce in a short but highly significant article in the *Century* for March, 1899. This article attracted very little attention at the time of its publication and seems hardly to have been referred to since then. Yet, at least to my own mind, no more noteworthy consideration has ever been given to this subject, and, coming from Lord Bryce, the opinions there expressed are naturally entitled to great weight. The article deals with "British Experience in the Government of Colonies." There are three types of colonies, distinguished from one another by climate and also by race and form of government. These are named temperate, subtropical and tropical. In temperate colonies the people from the mother-land live and thrive; do outdoor work; bring up strong and healthy children, and do not need a continued immigration of the home stock in order to maintain the race at its prime of physical and mental vigor. In the subtropical colony the colonizing race can not perform steady, hard labor, although it is able to live and maintain itself in health generation after generation. In the tropical colony Europeans, by reason of climatic limitations, can neither do outdoor labor nor keep their bodily and mental vigor. Children born in such climates are usually weak and sickly. Exceptions to this general rule are found in the Hawaiian Islands, "so far favored by their oceanic position," as Lord Bryce put it, "as to be a healthful dwelling-place for Americans and Englishmen; and the same remark applies to parts of the high inland plateau of South Africa, situated north of the tropic of Capricorn."

European races have occupied the temperate colonies, as, *e.g.*, North America, Australia, the cooler parts of South America; the bulk of the people are or will be European and have developed or will develop European institutions and a European type of civilization. The population of the subtropical colonies is chiefly, or largely, non-European. The laboring class, which makes up the bulk of the population, belongs to a lower type of civilization; it is usually native to the soil, although in the case of the Chinese and the Japanese in the Hawaiian Islands, the Indian coolies in Natal, and the Negroes in Cuba, the labor was imported. There are thus two different classes, usually sharply separated. In the typical tropical colonies, among which Lord Bryce placed central Africa, Madagascar, northern and eastern South America, British India, Java, Borneo and the Philippines, the race distinction is even more obvious. The Europeans or Americans are few, while the native or colored population is very large, and,

with certain exceptions, has a low type of civilization. The immigrant white population is relatively small; it is not acclimated; it is not there to stay.

In the temperate colonies the institutions are similar to those at home because the people are used to a civilized administration and to a constitutional form of government, and are capable of carrying them on. Canada and Australia are examples. The problems of government are inevitably very different in subtropical and tropical colonies. Here there is not one homogeneous race, imported from the mother-land, but there are two or more races. The native race, usually colored, is distinctly in the majority, and is in occupation of the agricultural and pastoral land. It is inevitable that the relations of the upper and the lower groups of the population should present many very complex and difficult problems, as, *e.g.*, the adjustment of the social relations. A survey of the history of subtropical colonies in British South Africa and in Algeria, and of tropical colonies in India, the West Indies, Ceylon, Fiji, Tongking, Madagascar, the Congo region and East Africa, led Lord Bryce to the conclusion that "it is . . . possible to have a species of representative self-government in [the] . . . subtropical territories. True, it is not a government by the whole people, *i.e.*, by the inhabitants generally. It is government by the European minority only, yet so far as this European part goes, and when viewed from the side of the mother-country, it is self-government."

In the case of the typical tropical colonies, if they are to have representative government, that government must follow one of two methods. One would give the suffrage to all the natives, or at least to the upper class of natives. The second would restrict the suffrage to the white population. There are obvious objections to either method. Great Britain's experience with both methods, in one form or another, was not encouraging. Other systems of government, tried in various forms, are also considered in Lord Bryce's article. "In all these colonies—and the same remark applies to India—the home methods of self-government have been rejected as unsuitable." A despotic government has been the one which, to quote from Lord Bryce, the English have been "obliged to apply to their tropical colonies" in which the white population is a relatively small, temporary and fluctuating one, with the great mass of the people far too ignorant to carry on any representative form of government. "Only through despotic methods," Lord Bryce wrote, "could have been done for India what the English have done. . . . These things have been achieved by an efficiently organized civil service, inspired by high traditions, kept apart from British party politics, and standing quite outside the prejudices, jealousies and superstitions which sway the native mind."

The question of the government of tropical colonies or protectorates or mandates is one for the future rather than of the past. As Lord Bryce clearly showed, the character of the population determines the form of government, and is itself very largely determined by the climatic limitations on white settlement and acclimatization. The classification of colonies on a climatic basis is fully justified. Such a classification commends itself to the climatologist as logical and simple, and it was suggested by one of the greatest authorities on government. It is, therefore, doubly justified. In looking into the future, one consideration may perhaps eventually have considerable importance, and that is the fact that the Mediterranean peoples on the whole become more readily acclimated in the hot, moist tropics than do those who come from the

higher latitudes. Also, the Latin peoples have far less prejudice against intermarriage with the native.

The very Europeans who exercise the controlling power in the tropics themselves tend to become enervated if they live there long; they lose many of the standards and ideals with which they started; they not uncommonly tend to fall towards the level of the natives rather than to raise the standards of the latter. The peculiar situation which may arise from the government of a tropical possession in which the white race does not become acclimated was emphasized some years ago by Dr. Goldwin Smith in a discussion of British rule in India. "British Empire in India," he said, "is in no danger of being brought to an end by a Russian invasion. It does not seem to be in much danger of being brought to an end by internal rebellion. Yet it must end. Such is the decree of nature. In that climate British children can not be reared. No race can forever hold and rule a land in which it can not rear its children." Or, as a recent English writer has put it:

> The natives, better suited to the conditions (of heat, light, disease, and the like), persist, and under the peace we have brought, multiply at a rate with which our own hampered immigration can not keep pace. Judging by the analogy of all history, our ultimate and certain fate in them is absorption or expulsion. A handful of aliens can not forever control multitudes to whom they teach their own arts. Even over South Africa, where natural conditions are least adverse, hangs the shadow of ultimate native predominance.

It would seem as if the development of agriculture on a large scale in the tropics, in order to provide a future food supply, would be a very simple matter. Here are immense areas with heat, humidity and deep soils; where frost is unknown; where high winds are very infrequent, and where it is always summer. All the conditions seem to be favorable. But the real facts in the problem are very different. Tropical soils are far less fertile and far less available for agriculture than is generally supposed. The warm heavy rains leach out the soil, carrying off many salts valuable as plant foods and leaving the land poor. Hence it becomes a common practice for the tropical farmer in the forest clearings or at the edge of the forest to plant a new patch of ground every year or so. Clearing land in the dense forests of the equatorial belt is very difficult, even almost impossible, owing to the dense growth of vegetation and to the rapidity with which the trees come back onto the cleared spaces. If cleared, the heavy rains wash the soil down the slopes. Weeds grow with almost inconceivable vigor; harvesting is interfered with by the rains; there are innumerable insect pests, blights and rusts; road construction is expensive and difficult; fevers of many kinds and other ailments are a serious handicap; the rains fall in such heavy showers that they are often damaging rather than helpful.

The savannas offer more favorable opportunities for agriculture in the fact that they are open grasslands, and no forests need to be cut down, but their soils are usually poorer than those in the forests, and the dry season, while good for clearing, tilling and harvesting, is often so deficient in rainfall that widespread droughts prevail, crops fail and famine follows. There is no doubt that these savannas will, in time, be more thickly populated and more valuable than now, especially where irrigation can be practiced. Under the supervision of white overseers, the natives will become better agriculturists and cattle-raisers. Some years ago, when, as a member of the Shaler Memorial Expedition, I spent part of a summer on the interior campos of southern Brazil—those vast stretches of grassland and of

scattered tree growth which make up so much of that country—the one question which was borne in upon me every hour of the day was this: What is to be the future of these vast savannas? To-day they are simply examples of colossal waste—waste of space; waste of soil; waste of rainfall; waste of sunshine. Fire devastates them, far and wide. Coarse grass, not eaten by cattle, covers square mile after square mile. Only here and there, as yet, at long intervals, at some lonely hut, was there any attempt to make the soil produce anything except the natural grass; only occasionally did I see a small herd of cattle or horses; only at long distances apart are there towns.

Yet these great campos certainly have a future. Nature has provided a climate better than that of much of the western United States. The high temperatures and abundant rainfall of the summer are followed by glorious bright, warm days and cool nights in the dry winter. There are drawbacks, of course. The dry season, the heavy thunderstorm, the hail, the frost, are to be reckoned with. But where the soil is ploughed and worked, it yields good grass for cattle and horses. Even now, thousands of cattle and horses could be pastured where all is still waste land. Where the attempt has been made, in the towns and around the huts, vegetables are to-day successfully raised. The problem is essentially one of time and labor and intelligent adaptation of crops to the climatic conditions. Cattle and sheep raising, and later farming, will come. Experiment stations must be established at various points. Wheat and cereals of different kinds can surely be found that will do well under the conditions of climate and soil which here exist.

These campos are no more unpromising than was, a few years ago, much of our own western country, where to-day are seen fields of wheat or of corn or of alfalfa. The shriek of the locomotive, not yet heard over great districts which I crossed, has meant the beginning of the development of that country. A farming and cattle-raising population will come in, as it came into our West. What is needed is a large influx of sturdy peasants from the north of Europe, who will not be afraid of hard work; who will intelligently till the soil and care for their crops; who will adjust their crops to their environment.

In the future, with increasing exploitation by the white race and under its control, and with growing demands on the part of the natives themselves, tropical industries are certain to develop. Such development has already taken place to a surprising extent, as in the mills and factories of India, for example. Great industries can be developed in tropical countries, although they are and will be handicapped by the lack of steady and efficient workers. Here, again, the introduction of labor-saving machinery, to replace as many native workers as possible, will solve many of the present problems. Machines do not feel the tropical heat. They do not need to become acclimated. They can be made to work steadily. And they require the supervision of relatively few skilled white machinists and operators. It is an interesting fact that both the United States and European countries have invented and manufactured machines especially intended for harvesting and preparing for export the products of the tropics, such as machines for splitting coconuts; for preparing and extracting oil from the palm; for pulping, hulling and sorting the coffee bean, and so on. The future will witness the use, in large numbers, of cultivators and harvesters made in extra-tropical latitudes, and of industrial machinery of many kinds.

In the future, also, the white man will make life far more comfortable, and safer, in the tropics by building houses better suited to tropical climates; by the wide-spread use of electrical cooling and ventilating devices; by constructing buildings which will, so far as possible, resist the terrific force of the wind in the districts visited by tropical cyclones. Acclimatization of the white race in the tropics can not be accomplished by any of these methods. That individuals from colder climates may live in the tropics, some of them for years, without any serious impairment of health, is true. But the general consensus of expert medical opinion to-day is that, for the white race as a whole, acclimatization is and always will be impossible. By acclimatization is here meant that, by and large, successive generations of white men, even if they are fortunate enough to escape all specific tropical diseases, can not live in the tropics without serious impairment of their physical and mental vigor.

FACILITIES IN BRAZIL, ARGENTINA, CHILE AND PERU FOR BOTANICAL INVESTIGATION AND TRAVEL

By the late Professor JOHN WILLIAM HARSHBERGER

UNIVERSITY OF PENNSYLVANIA

A COMMITTEE on the preservation of natural conditions of the Ecological Society of America with the assistance of numerous organizations and individuals prepared under the editorship of Victor E. Shelford and Forrest Shreve and a corps of associates and special editors a volume entitled "Naturalists' Guide to the Americas." It was printed at Baltimore in 1926 by the Williams and Wilkins Company. It is illustrated by some sixteen figures, and the areas treated are provided with bibliographies. The volume provides data about all the natural areas and regions of North America, including Central America, Panama and the West Indian islands. The natural history of northern South America is presented in about fifty-eight pages. The following South American states are described with the names of the collaborators: Colombia (Francis W. Pennell), Venezuela (H. Pittier and H. B. Baker), the Guianas (William Beebe and H. A. Gleason), Ecuador (Wilson Popenoe and H. E. Anthony), the Amazon Valley (Orland E. White). It will be noted, therefore, that Peru, Bolivia, Chile, Paraguay, Uruguay, Argentina and all Brazil approximately south of the tenth degree of north latitude have been omitted from consideration in the "Naturalists' Guide to the Americas." The following notes have been assembled with the idea of presenting facts which the writer collected on botanical travel in central and southern Brazil, Argentina, Chile and Peru during the summer of 1927.

Means of Access: The Munson Line and Lamport and Holt Line of steamships furnish passenger service to the east coast of Brazil. The steamers of the Munson Line are comfortable and commodious; they run directly from New York to Rio de Janeiro, and take two weeks to make the passage outside of the Bermuda Islands. Fairly good weather may be expected during the northern summer between New York and Cape San Roque, the easternmost point of Brazil. The same lines can be used on the return trip to New York. If the naturalist elects, he can return from Valparaiso in Chile by the Grace Line steamers, which stop to load freight and passengers at various ports in Chile and Peru, such as Antofagasta, Iquique, Arica (Chile), Mollendo, Callao (Lima), Salaverry, Talara (Peru). The route of the Grace Line steamers is through the Panama Canal, with stops at Balboa (Pacific side) and Cristobal (Atlantic side). It takes three weeks to make the trip from Valparaiso to New York. The Munson Line and Grace Line are operated by Americans, while the Lamport and Holt Line is English.

Hotel Accommodations: Modern hotels equal to the best in the larger cities of the United States are found in Rio de Janeiro, São Paulo, Buenos Aires and Valparaiso. The rooms, the service and the cuisine are excellent. If the naturalist takes one of the larger cities as his center of operations he will find hotels less high priced than the best with fairly good accommodations, as he can at home by choosing the less expensive hostelries. In such inland towns as Campos do Jordão, Santa Maria and Uruguayana, Brazil, the hotels are fair. One excep-

AN ANT-INHABITED TREE, *CECROPIA ADENOPUS*

IN MOUNTAINS BACK OF RIO DE JANEIRO, BRAZIL, AND ABOVE PAINEIRAS, JULY 18, 1927.

INTERIOR VIEW OF TROPICAL RAIN FOREST

ABOVE TIJUCA, RIO DE JANEIRO, BRAZIL, JULY 20, 1927.

SAND DUNES

ALONG COAST ENVIRONS OF RIO DE JANEIRO, BRAZIL, WITH TERRESTRIAL BROMELIAD, *Aechmea nudicaulis*, JULY 16, 1927.

tion was found at Mendoza in western Argentina where an exceptionally good hotel was found, the Hotel Plaza.

Vegetation Worthy of Study: The mountains behind Rio de Janeiro within easy access of the city by electric trolley lines, by autobus and by railroad are covered from bottom to top with a tropical forest. If the time of the botanist is limited, the tropical rain forest may be reached by ascending the Corcovado, (710 meters, 2,329 feet) from which a magnificent view of the city, the ocean and the country is to be had. A good trail leads down to Paineiras, where there is a hotel and restaurant, or farther down the mountain to Silvestre. This trail leads directly through the tropical rain forest and is advantageous for taking photographs or noting the general character of the vegetation, which would not be possible if one had to force his way through the dense growth. From Silvestre, the Estrada da Lagoinha can be followed to Sumare and then down into the city, or Rua de Aqueducto can be used down through Bella Vista into the Santo Antonio section of Rio de Janeiro. Another excursion can be made to the waterfalls and the rain forest of Tijuca. The restinga, or coastal thicket association with nearby dunes, can be investigated beyond Copacabana at Ifanema, where fresh-water marshes and granite cliffs harbor interesting rock algae, lichens, mosses and flowering plants (*Tillandsia aranjei*, etc.). The color of the granite cliffs, due probably to the growth of blue-green algae, suggests the Piedras Negras in Angola, Africa, the black color of the rocks there being due to algal incrustations.

Proceeding south from Rio de Janeiro by the Central Railroad of Brazil to Rezende Station, a side trip can be made to Bocaina, where the Sierra Bocaina can be ascended. Here *Araucaria brasiliana* begins to make its appearance on the mountains. Beyond Rezende Station is Homem del Mello, from which place the ascent of Itatiaia is possible and the botanist can acquaint himself with the vegetation of the highest peak of the Sierra Mantiqueira so ably described by Dusen. At Pindamonhangaba an electric train will take the visiting scientist to Campos do Jordão. Campos do Jordão is 1,573.80 meters (4,952 feet) in altitude and is distant from Pindamonhangaba about forty-seven kilometers.

Here is an excellent place to investigate the vegetation of the rolling savannas, or campos, and the groves of *Araucaria brasiliana,* but the botanist should be careful about the hotel at which he stops, for Campos do Jordão is a resort for Brazilians with tuberculosis and inadvertently the disease might be contracted. A preliminary cross section of the vegetation between Pindamonhangaba and Campos do Jordão revealed cleared and cultivated land, river marshes and swamps, savannas, savanna forests (*cerradão*), second growth timber (*caapueira*), rolling campos with scattered palms and trees, rain forest up to 1,500 meters (4,500 feet), upland campos from the upper limit of the rain forest to 5,600 feet alternating with groves of *Araucaria brasiliana.*

São Paulo in the heart of the coffee district has some interesting fresh-water marshes (fenland) near its outer limits. It is feasible to visit Alto da Serra and the biological station there, for the rich tropical rain forest can be penetrated by means of trails which have been constructed to facilitate the study of the vegetable life consisting of palms, tree ferns, orchids, bromeliads, filmy ferns and lianes.

The rolling campos country extends into the Brazilian State of Parana. On July 28, 1927, a white frost covered the campos, where herds of cattle were feeding. Araucaria forests alternate with the open country, and as one proceeds southward by rail to Vallinhas and Teixeira Soares, the valleys and hill slopes are covered with pure stands of Parana pine (*Araucaria brasiliana*). Saw-mills are found at a number of stations as at Fernandes Pinheiro where the araucarian logs are piled high preparatory to being sawed. Iraty would be a good place to stop on the main railroad line to study the Parana pine forests, for there are two small hotels here, the Hotel Estrella and the Central Hotel, where the botanist might stay while investigating the forest vegetation.

The summer-green forest of deciduous and evergreen broad-leaved trees is characteristic of the State of St. Catharina

LARGE *ARAUCARIA BRASILIANA*, CAMPOS DO JORDÃO

AT 5,000 FEET ELEVATION, BRAZIL, JULY 23, 1927.

HILLY CAMPOS ABOVE 5,000 FEET

CAMPOS DO JORDÃO, BRAZIL, JULY 23, 1927. NOTE GROVES OF *Araucaria brasiliana* AND *Podocarpus Lamberti* IN THE DEPRESSIONS BETWEEN THE ROUNDED HILLS.

around Pinheiro Preto. Bamboos occur in the forest, a tall flexuous Cocos and bromeliaceous epiphytes, although on the tops of the ridges *Araucaria brasiliana* is seen occasionally. The southern limit of *Araucaria* in this direction seems to be at Herval before crossing the Uruguay River into the State of Rio Grande do Sul at Marcellino Ramos. At Pulada, the boundless prairie plain, or pampas, is entered and this plain is broken by groves or longitudinal forests of *Araucaria,* which occupy the depressions. This type of vegetation can be studied by a stop at Carasinho, where there is a small hotel (Hotel Familiar), or at São Bento the Hotel Rio Grandense. The size of the campos forest groves here is indicated by the number of *Araucaria* trees found in them. Porongas is the absolute southern limit of the *Araucaria.* South of Cruz Alta herds of rhea, or South American ostriches, are encountered on entering upon the limitless pampas. Santa Maria is an important inland city, and Uruguayana in southwestern Brazil is on the Argentine frontier on the Uruguay River.

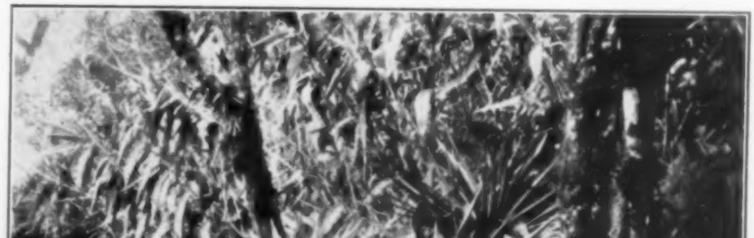
The ride on the railroad from Libres to Buenos Aires is comparatively uninteresting until the Parana River is reached with its extensive river marshes (fenland). Here the tall clumps of pampas grass (*Gynerium argenteum*) with waving plumes are at their best. The trains are carried across the fen country on large ferry-boats with a good opportunity to see the marsh vegetation. Many of the marsh islands have been planted to poplars and willows, which have grown up to form the alamos. The trees furnish firewood in a country naturally destitute of forest.

Buenos Aires can be used as a center for the investigation of the vegetation of the pampas. The writer was in Buenos Aires during the latter part of the southern winter, and on a visit to La Plata he stopped at Conchitas where the pampas seemed least disturbed. Here the pestiferous character of the cardoon (*Cynara Carduncułus*) was noted as this weed encroaches on the natural pampean vegetation. The Italian settlers must exercise constant vigilance to keep it in subjection. In crossing the pampas of Argentina from Buenos Aires to Mendoza, a gradual imperceptible ascent is made to the eastern foothills of the Andes, across a plain tilted in an east-west direction. The eastern part of this plain has been set-

tled, but the western part before reaching the vine-growing districts about Mendoza remains wild, open country with flocks of rhea encountered as one proceeds.

After leaving Mendoza by the Transandine Railroad the country becomes more rolling and more deeply dissected, resembling the western plains or the steppes of the eastern foothills of the Rocky Mountains in its topographic configuration. The vegetation, however, resembles the desert plains or mesas of the Colorado and Mohave deserts owing to the presence of a desert shrub *Covillea (Larrea) divaricata*, related generically to *Covillea tridentata* var. *glutinosa* of the northern plains. An interesting phytogeographical problem is presented in the distribution of the species of *Covillea* and other associated plants in North and South America separated by tropical vegetation. Mendoza might be made the center for such botanical investigation.

Reaching the western slopes of the Andes, the distribution of plants on Mount Aconcagua, the highest mountain in North and South America, might be studied, especially the altitudinal arrangement of the plants of the several belts. The presence of many species of the subantarctic forest on the Pacific slopes of the Andes along the Transandine Railroad would yield a rich botanical harvest. Santiago, Valparaiso and Puerto Montt might be used as centers for the study in detail of the vegetation of southern Chile. All these places are connected by railroad. With a seaworthy launch the channels and archipelago of islands as far south as the Strait of Magellan can be reached from Puerto Montt, as also the subantarctic forests where *Araucaria imbricata* and species of *Nothofagus* occur. Las Zorras, reached by electric car from Valparaiso, and Torpederas on the west coast are accessible to the botanist and should be visited during the spring and the summer of the southern hemisphere. A newly opened railroad to Lake Nahuelhuapi on the border between Patagonia and Chile will enable the botanist to



TERRESTRIAL BROMELIADS

IN TROPICAL RAIN FOREST AT ALTO DA SERRA, BRAZIL, JULY 26, 1927.

SHRUBBY LOBELIA, *LOBELIA SALICIFOLIA*
CHAPPARAL AT LAS ZORRAS, VALPARAISO, CHILE, AUGUST 15, 1927.

reach some of the least-explored parts of the subantarctic forests and also the Andes south of the 40th parallel of south latitude.

Botanical Gardens and Scientific Institutions.—The large and interesting botanical garden (Jardim Botanico) in Rio de Janeiro is reached easily by electric car from the heart of the city. It has a magnificent situation in a depression between two mountains covered with tropical rain forest. The forested slopes come down to the upper edge of the botanical garden, so that the planted grounds and the virgin forest are in juxtaposition. The Brazilian government should include the forested mountain slopes from base to summit with the Jardim Botanico and construct trails through the virgin forest, so that the wild vegetation would be preserved and would be open for study to visitors and scientists interested in the life of tropical regions. There would then be cre-

PAMPAS AT CONCHITAS, ARGENTINA
COVERED WITH INTRODUCED, WEEDY CARDOON, *Cynara cardunculus*, AUGUST 9, 1927.

ated a wild botanical garden and a cultivated one. In the Jardim Botanico there is a laboratory and museum building at one side of the garden where the botanical specimens are housed and a herbarium.

The Museum Nacional, which occupies the old imperial palace, is located in a large park planted with many interesting tropical trees. Several rooms are devoted to botany. Sala Freire Allemão contains a collection of the trunks, samples of rubber, fruits and mounted herbarium specimens with three oil paintings by Santos on the walls representing Amazonia, or Hylaea, Campos and Araucaria forest. Sala Martius Botanico is devoted to herbarium specimens arranged in cases according to natural families, to pictures of vegetation, to wood samples, to alcoholic fruits and to phytogeographic maps. There are oil paintings of Martius, Jacques Huber, Barbosa Rodrigues, Nicolão Moreira, and models of flowers by D'Émile Deyrolles, of Paris. Sala Conceição Vellozo has alcoholic specimens, paintings of water lilies, jack fruit and Victoria regia. The private gardens of the wealthy Brazilians and the city parks also present opportunities for the investigation of exotic cultivated plants.

Escola Superior de Agricultura e Veterinaria de Estado Minas Geraes at Viçosa is presided over by an American scientist, P. H. Rolfs, formerly of the Florida Agricultural Experiment Station. It is a center for the scientific study of agriculture and horticulture. The "priest's room" has been set aside for visiting botanists.

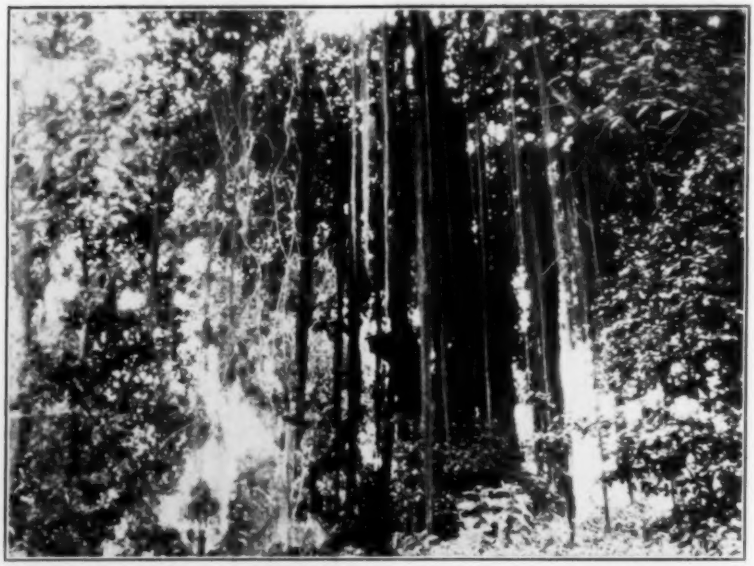
JARDIM BOTANICO, RIO DE JANEIRO, BRAZIL

WITH THE CORCOVADO IN THE BACKGROUND, PALMS ON HILL SLOPES AND SHRUBS OF *Azalea* (*Rhododendron*) *indica* IN THE FOREGROUND, JULY 15, 1927.

Estacão Biologica do Alto da Serra is situated on a hillside in the midst of a dense tropical forest. Here is a building used in part as residence for the caretaker and in part as a laboratory. The botanical garden, coincident with the tropical rain forest through which broad foot trails have been constructed, is thus accessible in all of its parts. The sta-

GROUP OF PALMS IN BOTANICAL GARDEN

AT BUENOS AIRES, ARGENTINA, AUGUST 5, 1927. THE LOW PALMS IN FRONT OF THE GROUP ARE *Washingtonia filifera* AND *Chamaerops humilis*. THE TALL PALMS ARE *Phoenix canariensis*.



JARDIN BOTANICO, LIMA, PERU

LARGE FIG TREE, *Ficus sp.*, WITH ROPE-LIKE, HANGING AERIAL ROOTS, AUGUST 24, 1927.

tion is controlled by the Chefe da Secção de Botanica de Museu Paulista and as the official publication appears Archivas de Botanica de Estado de S. Paulo. In this forest are tree ferns, epiphytic bromeliads and orchids, tall forest trees draped with lianes and filmy ferns.

Museu Paulista in the environs of São Paulo has a room in which botanical and herbarium specimens are displayed and in the City of São Paulo is located the herbarium and botanical library on the second floor of No. 31 Rua Conselação, over an agency for Ford automobiles. Dr. F. C. Hoehne is the able director in charge. There is a botanical garden (Horto "Oswaldo Cruz") associated with the Instituto Butantan. One section of the grounds is devoted to a snake farm, where poisonous reptiles are kept to secure their venom for remedial and experimental purposes. Butantan is one of the suburbs of São Paulo.

The Jardin Botanico in Buenos Aires is richly stocked with plants arranged in systematic beds. One section of the garden consists of a geographical arrangement. Here one finds segregated Argentinian, Brazilian, Chilean, Australian, Uruguayan, European, North American, African, Asian and Japanese plants. Unusual opportunity is given for the study of trees of northern climes growing in the southern hemisphere.

The public gardens adjoining the botanical and zoological gardens are well worth a visit. La Plata is reached by Ferrocarril del Sud. The celebrated museum is reached best by taxicab from the railroad station. A small room is devoted to the botanical collections.

The botanical garden at Santiago, Chile, is a fine one. Although Valparaiso does not have a botanical garden, it has in Jardin Suizo, owned by Benjamin Pümpin and his son Enrique, at Las Zorras, a large collection of exotic and native species grown for ornament and for sale. The catalogue of the Jardin Suizo is useful as an indication of the exotic and native plants which can be grown in southern Chile.

The City of Lima, Peru, boasts a school of pharmacy connected with its university. The building of the school of pharmacy is located in the Botanical Garden, which has a large and representative collection of plants of temperate and tropical regions and is a center of botanical influence on the Pacific coast of South America.

Altogether a survey of the facilities for botanic investigation and travel in Brazil, Argentina, Chile and Peru indicates that the botanist will find much of interest in the botanical gardens and institutes maintained for the scientific study of plants, but above all the comforts of home need not be sacrificed by a prolonged stay in order to investigate the native flora and the vegetation, which present many features of absorbing interest.

HYPNOTISM IN SCIENTIFIC PERSPECTIVE

By Professor CLARK L. HULL

UNIVERSITY OF WISCONSIN

PHENOMENA more or less resembling those of the hypnotic trance appear to have been known from very early times, especially among oriental peoples. For the most part, these states were associated with religious and mystical practices. While of interest to the curious, this phase of the history of hypnosis has left no tangible contribution to science. It is sufficient to observe that hypnotism originated in magic just as chemistry arose from alchemy and astronomy from astrology.

About the time of the American Revolution Franz Anton Mesmer (1733–1815), a Viennese physician, put forward to the scientific world the theory and practice of what he called animal magnetism. Mesmer's medical training naturally made his interests clinical. No doubt the spirit of the times tended to tinge his practice with something of the mystical. In any case, having failed of success in Germany, he went to Paris in 1778 where he soon had a tremendous vogue. There he opened a remarkable clinic in which he treated all kinds of diseases.

The clinic was held in a large hall which was darkened by covering the windows. In the center of this room was a large oaken tub, the famous *baquet*. The tub was filled with water into which had been placed a quantity of iron filings and ground glass. Over the tub was a wooden cover provided with openings through which projected jointed iron rods. These rods were applied by the patients themselves to their various ailing parts. While at the tub, the subjects were commanded to maintain absolute silence, possibly to render them more susceptible to the plaintive music that was provided. At the psychological moment, Mesmer would appear on the scene garbed in a brilliant silk robe. He would pass among the patients, fixing his eyes upon them, passing his hands over their bodies and touching them with a long iron wand. Individuals apparently suffering from the most varied disorders declared themselves cured after two or three such treatments.

Mesmer did not hypnotize his subjects, although some of them appear to have had spontaneous hysterical convulsions and to have shown other related behavior while at the tub. The sleeping trance which is a familiar part of hypnotism today seems to have been discovered accidentally in 1784 by a follower of Mesmer, the Marquis de Puységur. One day he attempted to apply Mesmer's magnetizing methods to Victor, a young shepherd, who, instead of showing the usual hysterical convulsions, fell into a quiet sleeping trance. Without awaking, he later went about his duties like a sleep-walker. When he finally awoke from his somnambulistic state, he was unable to recall anything that had happened while in it. Victor's inability to recall the trance events would now be called post-hypnotic amnesia. The sleeping or trance condition was quite naturally regarded as an artificially induced somnambulism and at once it attracted a great deal of attention, partly on account of the supposed clairvoyant powers of subjects while in this state. About the same time Pététin, a physician at Lyons, described the phenomenon of hypnotic catalepsy or muscular immobility. The discovery of the remaining major hypnotic phenomena followed rapidly, and by 1825 hypnotically induced positive hallucinations (seeing

F. A. MESMER (1733–1815)

things which are not present), negative hallucinations (being blind to things really present), hypnotic anesthesias, analgesias (insensibility to pain), and the action of post-hypnotic suggestion had all been clearly described.

The theories of animal magnetism as put forward by Mesmer and as elaborated by his followers are of considerable scientific interest, not because they were true, but because, on the contrary, it took the world such a long time to realize that they were false. In 1766 Mesmer wrote his medical dissertation on the influence of the planets upon the bodies of men. This survival of the traditions of astrology he combined with the theory that the two lateral halves of the human body act like the poles of a kind of animal magnet. Disease was caused when there was an improper distribution of this magnetism within the body. Animal magnetism itself was held to be a kind of impalpable gas or fluid, as distinguished from the magnetism of minerals. The distribution and action of animal magnetism were supposed to be under control of the human will. Mesmer's followers even thought that this strange fluid could be seen. Trained somnambulists were supposed to behold it streaming forth from the eyes and hands of the magnetizer, though they disagreed as to whether the color of the strange fluid was white, red, yellow or blue. It was agreed, however, that the fluid could be confined in a bottle and thus transported, exerting its mystical power in distant places!

The century which has elapsed since 1825 has been much less fertile in the discovery of hypnotic phenomena than the preceding half century. Indeed almost the only outstanding events during this period have been the gradual though still incomplete correction of errors which accumulated around the pseudoscience of hypnotism previous to that date. One of these is its approximate escape from its age-long entanglements with mysticism and magic. A second and more dramatic episode is the struggle centering around the rivalry between the objective theories of animal magnetism and the subjective theory of suggestion as alternative explanations of hypnotic phenomena. It is with events of this latter confliet that we shall now concern ourselves.

The subjective or psychological nature of hypnotic phenomena seems independently to have been discovered and

published by James Braid in England (1843) and by a group of French investigators beginning with the Abbé Faria (1819) and culminating with Liébeault (1866) and Bernheim (1886). In contrast with the French movement, Braid's stroke of insight appears to have been a relatively independent and isolated event. In 1841 he witnessed a mesmeric séance conducted by a French magnetizer named LaFontaine. Braid first went to the demonstration suspecting fraud. Upon witnessing it a second time, however, and after making certain tests of the subjects himself, he became convinced that the phenomena were genuine. He later began experimenting extensively on his own account. This very soon led him to the view that the cause of the various phenomena was not a fluid which passed from the body of the mesmerist into that of the subject, but that in reality it all depended upon the suggestibility of the subject himself. Braid is, likewise, notable for having developed a special technique for inducing the trance, a method still extensively used. His procedure was to have the subject look fixedly at some bright object which was held near and slightly above the eyes in such a way that the eye muscles were under a certain amount of strain. This technique was usually combined with verbal suggestion. Braid utilized the trance mainly in his painless surgical operations, which he performed in large numbers. He also introduced the word "hypnotism" now in general use.

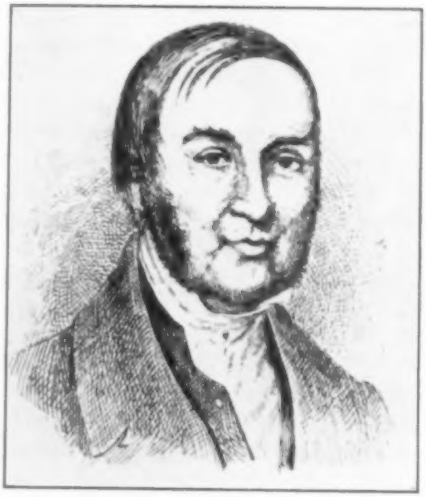
The parallel movement in France was much more complicated. It began in 1814–18 when the Abbé Faria showed by experiments, which were later published, that no special force was necessary for the production of the mesmeric phenomena such as the trance, but that the determining cause lay within the subject himself. One of Faria's subjects was a general named Noizet, who was converted to the Abbé's views. He, in turn, passed Faria's teachings on to a physician, Alexander Bertrand, who elaborated them. Both Noizet and Bertrand wrote books upon the subject.

Basing his opinion largely on the striking similarities between the systems of Noizet and Bertrand on the one hand and that of Liébeault on the other, Pierre Janet has advanced the view that Noizet's book may have fallen into the hands of Liébeault. In contrast to this Bramwell calls attention to the fact that Braid's anti-magnetic views were being exploited in France through the influence of Azam and others in 1859–60. In any case, we find Liébeault seriously beginning the study of mesmerism in 1860, but entirely rejecting the theory of a magnetic fluid.

Liébeault was a humble physician who began a country practice in 1850. In 1864 he settled at Nancy and practiced hypnotism among the poor peasants who came to his clinic. The temper of the man is shown by the fact that he accepted no fees for these services, living on his income. Bramwell, who visited Liébeault's clinic, draws such an inimitable picture of it that it must be quoted:

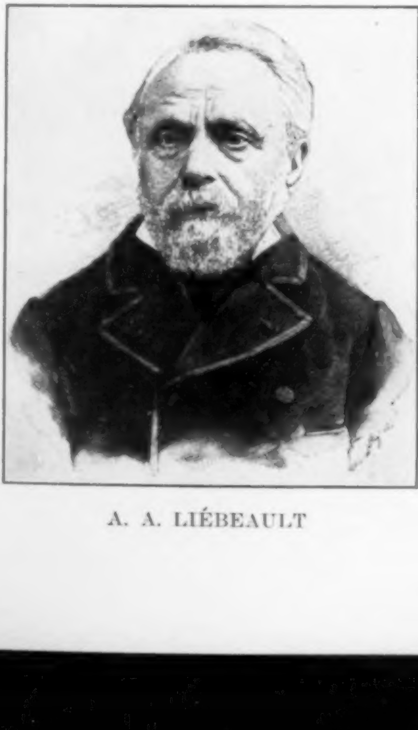
> His clinique, invariably thronged, was held in two rooms in the corner of his garden. . . . The patients told to go to sleep apparently fell at once into a quiet slumber, then received their dose of curative suggestions, and when told to awake, either walked quietly away or sat for a little to chat with their friends, the whole process rarely lasting longer than ten minutes. . . . No drugs were given, and Liébeault took special pains to explain to his patients that he neither exercised nor possessed any mysterious powers, and that all he did was simple and capable of scientific explanation. . . . A little girl, about five years old, dressed shabbily, but evidently in her best, with a crown of paper laurel leaves on her head and carrying a little book in her hand, toddled into the sanctum, fearlessly interrupted the doctor in the midst of his work by pulling his coat, and said, "You promised me a penny if I got a prize." This, accompanied by kindly words, was smilingly given, incitement to work having been evoked

in a pleasing, if not scientific way. Two little girls, about six or seven years of age, no doubt brought in the first instance by friends, walked in and sat down on a sofa behind the doctor. He, stopping for a moment in his work, made a pass in the direction of one of them, and said, "Sleep, my little kitten," repeated the same for the other, and in an instant they were both asleep. He rapidly gave them their dose of suggestion and then evidently forgot all about them. In about twenty minutes one awoke and, wishing to go, essayed by shaking and pulling to awaken her companion—her amused expression of face, when she failed to do so, being very comic. In about five minutes more the second one awoke, and, hand in hand, they trotted laughingly away.



JAMES BRAID (1795–1860)

After coming to Nancy, Liébeault began writing a book on hypnotism which was finished after two years of hard work. When published, however, only one copy was sold! But Liébeault patiently pursued his gratuitous labors among the poor for twenty years when, by a kind of accident, his remarkable work was finally recognized. It seems that Bernheim, a professor in the medical school at Nancy, treated without success for six months a case of sciatica which had lasted for six years. This patient was quickly cured through hypnotic suggestion administered by Liébeault. This striking cure caused Bernheim to investigate the novel method of treatment. His initial incredulity soon changed to enthusiastic admiration, and in 1884–6 Bernheim published an attractively written book in which he directed the attention of the world to Liébeault's work. In this tardy way, twenty years after it had been written, the remaining copies of Liébeault's book were finally sold, and the modest physician at last received recognition. Doctors from all countries now flocked to Nancy to study his methods.



A. A. LIÉBEAULT

But suggestion as an explanation of hypnotic phenomena was yet to encounter a severe struggle. Independent of Liébeault, Charcot, an anatomist and neurologist of Paris, had, around 1880, attracted considerable attention by his courageous experiments and lectures on the subject of hypnosis. Warned by the unscientific extravagances which had very properly brought the magnetizers into disrepute, Charcot resolved that his experiments, at least, should be ultrascientific and technically above reproach. It is largely because of this that the controversy which eventually grew up between the Paris and Nancy schools

merits our attention. For, despite Charcot's scientific intentions, no one has ever fallen into more grievous experimental errors or gone more widely astray in experimental method than he. This simply goes to show how easy it is, even with the very best of scientific ideals, to go hopelessly wrong in hypnotic experimentation.

Charcot seems to have been especially fearful of being deceived by his subjects. He therefore sought in their behavior for signs which could not be simulated. Apparently he never hypnotized any one himself but depended upon his assistants who brought the subjects to him. These were mainly three hysterical young women. With these mentally pathological subjects, he sought diligently for objective signs characteristic of the hypnotic state. Quite naturally he employed the same general methods that he had recently applied with success to the study of locomotor ataxia and lateral sclerosis. When the subjects were stimulated, their muscles seemed to show characteristic reactions following definite laws.

> All of these phenomena could be successfully linked to Charcot's earlier studies. They could be examined with the guidance of the same anatomical ideas. The same method and the same instruments could be used. The same little hammer could be used for testing the reflexes. As of old, demonstrations could be made by the chief to an admiring circle of pupils. It was still possible to seek upon the bared limb of the subject a place where a blow with the hammer would readily induce a well-marked contracture, and one plainly visible to all beholders. To Charcot this was irresistible. He declared that the study of such phenomena could be conducted by a perfectly sound method; that the method sufficed to exclude the possibility of fraud, which had invalidated the old experiments upon somnambulists; and that it was in the light of the data acquired by this method that a critical review of all the recorded phenomena of animal magnetism must be undertaken.[1]

Pursuing his methods just described Charcot reported a number of supposed discoveries. Major hypnotism, as it was now called, showed three sharply marked stages: lethargy, catalepsy and somnambulism. In the lethargic stage, induced by closing the subject's eyes, the subject could hear nothing and could not speak; but, when certain nerves were pressed, remarkable and uniform contractures resulted. If, while in the lethargic state, the subject's eyes were opened, she at once passed into the cataleptic stage, in which the limbs remained in any position they were placed by the experimenter, though she was still unable to hear or speak. Lastly, if friction were applied to the top of the head, the subject passed into the somnambulistic condition which was substantially that of the ordinary trance. Sometimes these contractures, catalepsies and other hypnotic manifestations appeared only on one side of the body. In such cases, if a large magnet were brought close to the limbs in question, the particular symptoms would be displaced at once to the other side of the body. This phenomenon was called *transference*. Thus, curiously enough, we find magnetism reappearing in the history of hypnotism, this time in respectable scientific garb, though quite as fallacious as when similar claims had been advanced by the old magnetizers.

To these claims of Charcot and his followers, Bernheim replied in the second edition of his book:

> If, in our researches, we failed to take as our starting-point the three phases of hysterical hypnotism described by Charcot, this was because we were unable by our observations to confirm their existence. We were unable to ascertain that the action of opening or closing the subject's eyes, or friction of the vertex, modified the phenomena in any way; or that in the subjects who were not disposed to manifest certain phenomena under the sole influence of suggestion, such phenomena could be induced by any of the physical stimuli just mentioned. . . . Conversely, all the phenomena can be readily obtained when they are described in the subject's presence, and when the idea of them is allowed to permeate his mind. Not only can all the classical effects of the magnet be induced

[1] Pierre Janet, "Psychological Healing," vol. 1, p. 168.

in this way, but the same thing applies to all the varieties of transference. I say, "I am going to move the magnet, and when I do so there will be a transference from the arm to the leg." A minute later, the arm falls and the leg rises. Without saying any more to the subject, I next move the magnet back to the leg; thereupon there is a fresh transference from the leg to the arm. *If, without disclosing the fact to the subject, I substitute for the magnet a knife, a pencil, a bottle, a piece of paper, or nothing at all*—still the phenomena are witnessed.[2]

The salutary manner in which Bernheim thus exposed by means of the control experiment the basic error in the experimental technique of the Paris school should be pondered long and well by all who essay experimentation in the field of hypnosis.

The conflict with Paris having been won, there was yet another chapter in the history of hypnosis and suggestion to be written in Nancy. In 1885 the good Liébeault met at Troyes a young druggist named Émile Coué. The two men at once found much in common. For a time Coué studied and practiced hypnotic suggestion according to

EMILE COUÉ

J. M. CHARCOT (1825–1893)

Liébeault's technique. Meanwhile he observed the influence of waking suggestion in effecting cures when associated with the use of drugs, the latter often quite innocuous in themselves.

He studied and brooded over the matter for a period of twenty-five years. In 1910, at the age of fifty-three, Coué established what has sometimes been called the "neo-Nancy" school. Following the example of his predecessor, Dr. Liébeault, Coué held his clinique in his own home and gave gratuitously his healing suggestions to the many who flocked to receive them. But his technique was different. Coué abandoned the trance entirely and depended wholly upon waking suggestion. This he called *auto-suggestion*, insisting that all suggestion is in reality nothing but auto-suggestion.

What Coué meant by the term, auto-suggestion, may best be understood from his quaint directions to a person suffering from pain:

Therefore every time you have a pain, physical or otherwise, you will go quietly to your room . . . sit down and shut your eyes, pass your hand lightly across your forehead if it is mental distress, or upon the part that hurts, if it is pain in any part of the body, and repeat the words: "It is going, it is going," etc. Very rapidly, even at the risk of gabbling, it is of no importance. The essential idea is to say:

[2] Quoted by Janet, "Psychological Healing," vol. 1, p. 182. Italics ours.

"It is going, it is going," so quickly, that it is impossible for a thought of contrary nature to force itself between the words. We thus actually think it is going, and as all ideas that we fix upon the mind become a reality to us, the pain, physical or mental, vanishes. And should the pain return repeat the process 10, 20, 50, 100, 200 times if necessary, for it is better to pass the entire day saying: "It is going!" than to suffer pain and complain about it.[3]

Such, in brief, is the history of hypnotism. All sciences alike have descended from magic and superstition, but none has been so slow as hypnosis in shaking off the evil associations of its origin. None has been so slow in taking on a truly experimental and genuinely scientific character. Practically all of the actual phenomena were discovered and described during the first fifty years, from 1775 to 1825. But the century since 1825 has shown a remarkable sterility in this field. Almost nothing of significance has been accomplished during this period except the very gradual correction of errors which originally flowed directly from bad experimental procedures. We have already had occasion to note a classical case of this in the controversy between Bernheim and Charcot. The tardy development of the science of hypnotism, moreover, is especially striking when it is recalled that practically from the beginning hypnosis has been definitely an experimental phenomenon. Not only this, but experimentation in it has been continuous and widespread through all of this period during which science in other fields has made the greatest advances ever known.

The paradox in this case, as always, disappears with full knowledge of the attendant circumstances. In the first place, as we have already seen, the dominant motive throughout the entire history of hypnotism has been clinical, that of curing human ills. A worse method for the establishment of scientific principles among highly elusive phenomena could hardly have been devised. As we shall have occasion to observe frequently, one indispensable principle of satisfactory hypnotic investigation is that of the control experiment. Thus Charcot's magnetic experiment was utterly misleading and scientifically pernicious until Bernheim completed it by substituting for the magnet "a knife, a pencil, a bottle, a piece of paper, or nothing at all." But deliberately to run a control experiment in genuine clinical practice involves withholding from a considerable number of patients (the control group) a mode of treatment possessing a certain presumption of curative value. This deliberate withholding of the means of life and health from certain individuals, even though on the long run it might greatly profit other individuals, is revolting to ordinary human nature. And, when individual patients are paying individual doctors for treatment, it is quite out of the question. The physician's task is to effect a cure in the quickest manner possible, using any and all means at his disposal more or less simultaneously. Naturally general laws which call for the varying of a single factor at a time do not readily emerge from such situations. Worse still (despite notable exceptions as in the case of Bernheim) the limitations of clinical practice often operate in the behavior of experimenters accustomed to them, even when the conditions surrounding the particular experimental situations are such as really to permit control experiments to be carried out.

What we have spoken of above as the control experiment has long been known and employed by scientific investigators. It is an integral part of the most potent of all scientific methods. This has been known since the time of John Stuart Mill as the "method of difference." According to Mill, it is "by the method of difference alone that we can ever, in

[3] "Suggestion and Auto-suggestion," Coué, p. 82.

the way of direct experience, arrive with certainty at causes." At bottom the method is very simple. Its procedure falls naturally into two parts. The first part is usually thought of as the main or basic experiment. The second part is what we have called the control experiment. It is the almost universal failure of the experimenters to perform part two as required by the method of difference that has proven so disastrous in the history of hypnotism.

In the main or basic experiment by the method of difference there is set up an experimental situation containing a factor *A* which is presumed to be causally active, along with attendant factors *B*, *C* and *D*, all of which are presumed in this particular situation to be non-active. What follows from the joining of these factors is then noted. The result *X*, whatever it chances to be, is likely by the unsophisticated to be taken forthwith as the effect of the antecedent *A*. Thus when Charcot brought the magnet (*A*) close to the contracted leg of the hypnotized subject and the contraction thereupon was transferred to the arm (*X*), he naïvely concluded that the specific magnetic property of the magnet was the active agent. As a matter of fact, no general conclusion whatever as to causation may safely be drawn at this stage of the experiment. It is always possible that the observed consequent *X* may have been caused by the supposedly neutral attendant circumstances *B*, *C* or *D*, or some combination of them, and not by *A* at all.

The second or control part of the method of difference comes in at this point to clear up the experimental ambiguity. In this part a new experiment is set up which is in all respects exactly like the first except that antecedent factor *A* shall be absent. If, now, the consequent *X* is also found to be absent, *then* the conclusion may be drawn that *A* is in truth the cause of *X*. But if, on the other hand, *X* should really be found among the consequents, it will be quite as clear that *A* is *not* the cause of *X*. This last is what happened when Bernheim carried out the control to Charcot's experiment. With everything else the same, a bottle or a pencil, or only the actions of the experimenter were quite as efficacious in changing contractures as was a true magnet.

No doubt an important factor contributing to the almost universal failure to perform satisfactory control experiments in the history of hypnotism has been the grossly inadequate training of the investigators. Up almost to the present moment their training, if any, has been in the non-mental sciences of physics, chemistry, physiology or anatomy. Almost without exception they have known little or nothing of the technique and peculiar pitfalls of psychological experimentation. The ordinary physicist, chemist or physiologist in his scientific training never encounters the phenomenon of substitution of stimulus (or cause) which takes place constantly in habit formation. Thus it seems never to have occurred to Charcot that a magnet could be causally active in determining human behavior except through its specifically magnetic properties. He did not realize the possibility that through maladroitness in the conduct of his investigations his subjects, even unknown to themselves, might acquire certain habits; that by virtue of these habits the stimulation of their sense organs by a magnet or merely by movements or sounds associated with the use of a magnet might alone evoke the observed reactions. The causal effects in this latter case were, of course, quite as physical as the action of a magnet on iron filings, though the mechanism involved was radically different from what Charcot implicitly assumed.

Despite the very devious and unscientific history of hypnotism, there is ex-

cellent reason to expect a decided change for the better in the near future. The excessive preoccupation with the clinical and other practical applications of hypnotism so characteristic of its history has now subsided to moderate proportions. This can hardly be regarded as anything but a fortunate circumstance for the development of hypnotism as a true experimental science and ultimately for its most effective application as well. Moreover, the rapid development of psychology as an experimental science within recent years has made available to the hypnotic investigator a large number of experimental methods and devices which he may utilize at once with little or no modification. Lastly there is reason to believe that a kind of renaissance in hypnotic research is actually on its way. At several centers of learning and research in this country alone there exists a vivid appreciation of the possibilities in this direction. From at least two of these is already appearing at fairly regular intervals a succession of papers describing really scientific and adequately controlled hypnotic investigations. It is not inconceivable that, profiting by its checkered past, hypnotism may one day occupy an enviable scientific position.

A PHARMACOLOGICAL APPRECIATION OF REFERENCES TO ALCOHOL IN THE HEBREW BIBLE

By DAVID I. MACHT, M.D., Phar.D., Dr.Litt. (Heb.)
THE JOHNS HOPKINS UNIVERSITY

INTRODUCTION

THE alcohol problem in the United States is at present of universal interest. While the question has been widely discussed from the sociological, psychological, political and legal aspects, the whole subject from the scientific point of view is primarily a medical one, and, more accurately speaking, belongs to the domain of pharmacology. No apology is therefore necessary for any investigation of a pharmacological character which may tend to throw more light on the subject, be that investigation of an experimental character or of a historical nature. The historical approach to the study of medical problems is now being recognized more and more as of great value in establishing a proper perspective of a given subject and often providing useful empirical data for carrying on experimental investigations. For this reason, the present sketch is deemed to fill a definite need, namely, to furnish reliable information concerning a subject which has been greatly misunderstood. No apologies are required for a scientific inquiry into references to wine and other alcoholic liquors mentioned in the Bible because of the incontestable fact that this literary work is truly the Book of Books, one which has been and is being read by the largest number of human beings in the world, and a book which has been translated into a greater number of languages than any other work. This universal appeal of the Book of Books may, on superficial consideration, be regarded as an argument against any new publication dealing with its contents as being superfluous. Such an argument, however, is not a valid one for two very good reasons. In the first place, the Bible has been dragged into the prohibition controversy by persons prompted more by acrimonious zealotry and bigotry than by a desire to understand correctly the work which they are quoting. In the second place, it is a platitude, which nevertheless is worth emphasizing, that no translation of any literary masterpiece can adequately convey either the sense or the spirit of the original text and, in the case of the Old Testament, references to alcohol have been based on quotations or misquotations from English translations of the Hebrew, many of which are preposterous and nonsensical. To appreciate fully the truths and the beauties of the Hebrew Tenach (Bible), it is absolutely necessary to have at least some acquaintance with the original text. To quote from an illustrious writer on the subject: "It must be read in Hebrew, that is to say, in accordance with the *spirit* of that language. It describes but little, but through the rich significance of its verbal roots, prints in the word a picture of the thing." A thorough acquaintance with the etymological denotations of these roots is essential for the adequate grasp of the complete idea or thought expressed in its consonants and simple words. "It only joins for us predicate to subject and sentence to sentence; but it presupposes the listening soul, so watchful and attentive that the deeper sense and profounder meaning, which lie not upon but beneath the surface, may be supplied by the logical and independent action of the mind itself. It

is, as it were, a semi-symbolic writing."[1]

In the present paper it is proposed, in the first place, to recapitulate briefly the status of pharmacological and toxicological knowledge concerning alcohol and, in the second place, in the light of such knowledge to examine critically the more important references to wine and liquor mentioned in the various books of the Old Testament. Such a critical study of the Bible will not be based on the reading of any one authorized version, but on a comparative study of various original texts and available translations as well as on philological investigations concerning the various terms encountered, out of which the most straightforward and clearest interpretations will be selected in the light of the latest pharmacological and medical data. It is hoped that such a contribution will be found useful both by specialists in the natural and medical sciences and by general students of Biblical history and philology.

Physiological Considerations

Although ethyl alcohol is generally discussed along with other alcohols in text-books on pharmacology, this particular compound is in a sense really not a drug at all and may be classed physiologically as a normal product of metabolism and, to a certain extent, as a food. Thus, a Japanese investigator, Morie Aoki,[2] has found that ethanol is a normal product of certain living cells. Again, both physiologists and pharmacologists are agreed that it is an excellent food in the sense of being a source of energy. It is completely oxidized in the body when small quantities are taken internally, and in that way supplies energy to the living organism. Thus, Starling,[3] in his "Human Physiology," states:

> When alcohol is taken by man in moderate quantities, the greater part of it undergoes oxidation and leaves the body as carbon dioxide and water; about two per cent., which escapes oxidation, is excreted unaltered by the lungs and kidneys. This oxidation of alcohol is a result of true utilization, since the addition of a certain amount of alcohol to the body does not result in an increased output of carbon dioxide. In small quantities, therefore, alcohol can act as a food.

This function, however, is not so important in normal individuals as in certain diseased conditions, especially in fevers and certain constitutional diseases like diabetes. In fevers, much larger quantities of alcohol are oxidized and liberate sufficient energy to take the place of at least a part of ordinary diet. According to Sollmann,[4] to quote from his standard reference book on pharmacology in connection with the use of alcohol in exhausting fevers:

> The intelligent and discriminate employment of alcohol should be useful in these conditions: its indiscriminate use would doubtless do more harm than good. The beneficial effects are probably mainly nutrient, due to the direct *food value of alcohol,* and to the stimulation of the digestion and absorption of other foods. This not only conserves the general nutrition of the patient but also increases the output of the exhausted heart. The pulse becomes stronger and more regular. The altered distribution of the blood by the mildest degrees of alcohol action would also be beneficial. The dilation of the cutaneous vessels removes the blood from the atonic, and therefore congested, internal organs and lessens venous distention of the heart. It would also tend to lower the temperature, although the antipyretic effect is but small. The narcotic action of the alcohol is useful by quieting the febrile excitement, thus reducing the demands on the strength of the patient.

In diabetes mellitus, alcohol, as would be expected, acts favorably as an easily digested food, supplying the place of the sugar and diminishing the excessive demand on proteins and thus lessening the risk of acidosis. This has been shown to some extent by the work of Benedict and

[1] Hirsch, "The Nineteen Letters," trans. by Drachman, Funk and Wagnalls, 1899.

[2] *J. Biochem.* (Japan), v, p. 71, 1925.

[3] "Human Physiology," p. 566, 1926.

[4] "Manual of Pharmacology," p. 640, 1922.

Török,[5] who found that the replacement of fifty to eighty grams of food fat by equivalent quantities of alcohol lessens the excretion of sugar, acetone and nitrogen. Neubauer[6] also found alcohol useful in diabetes, although other writers, such as Mosenthal and Harrop,[7] found that it was not able to replace protein or fat in conserving a nitrogen balance.

Pharmacological Résumé

The salient facts concerning the pharmacological action of ethyl alcohol are well established and are unanimously agreed upon by all investigators in pharmacology. Ethyl alcohol is a drug or chemical acting primarily upon the *central nervous system.* In the course of its action, depending on the dose, two stages can be distinguished. After small doses a sense of well-being and of "stimulation," or excitement, is noted. The feeling of well-being, or euphoria, is a characteristic feature of the action of the drug and manifests itself in a sense of comfort and relaxation, a feeling of greater confidence in oneself, greater freedom of speech and an increased buoyancy of spirits, so that a person who may be depressed becomes more sanguine and cheerful. This sense of "stimulation" produced by alcohol has been regarded by Binz,[8] one of the prominent earlier investigators in the field, as due to a true stimulation of nervous elements. Bunge,[9] however, who was another eminent worker in the field, regarded the "stimulation" as being due to a release of excessive inhibitions in the nervous system, allowing a freer play of psychological reactions. More recent and extensive psycho-pharmacological investigations, by Rivers,[10] Kraepelin,[11] Jacobi[12] and Benedict,[13] have amplified our knowledge concerning the action of ethanol. According to Kraepelin, the primary stimulating effect of ethyl alcohol is that it facilitates mechanical work through a stimulation of motor impulses, as indicated by experiments with the dynamometer. On the other hand, Kraepelin found that such mechanical processes as simple reactions, repetition of words, reading, etc., are made at the expense of the more complex mental processes and associations, so that very accurate intellectual work and finer judgments are impaired. The American investigators, Dodge and Benedict, found that ethyl alcohol not only depresses the sensory reactions, but does not produce any definite stimulation even of simple mechanical performance. All investigators, however, are agreed that whether the primary "stimulation" of the brain by alcohol be a true stimulation or merely a release of inhibitions, the effect upon the psychic state of the subject is to produce a sense of euphoria, or well-being, which is of great therapeutic value in cases of nervous strain, melancholia and other depressive states. Large or excessive doses of ethyl alcohol, however, exhibit the secondary stage of its pharmacological action, namely, the loss of coordination, stupor and, eventually, a complete paralysis of the central nervous system, leading to coma and death.

In addition to the effects upon the central nervous system, one of the most important properties of alcohol is its effect on the circulation. Here, again, all pharmacologists agree a stimulating effect is produced. This is due partly

[5] *Bioch. Centr.*, v, p. 1916, 1906.

[6] Cited by Sollmann.

[7] *Arch. Int. Med.*, xxii, p. 750, 1918.

[8] *Arch. f. Exper. Path. u. Pharmakol.*, vi, p. 312, 1877.

[9] "Die Alkohol Frage," Leipzig, 1887.

[10] "The Influence of Alcohol on Fatigue," London, 1908.

[11] *Bioch. Bull.*, v, p. 223, 1916.

[12] *Arch. f. Exper. Path. u. Pharmakol.*, xxxii, p. 49, 1893.

[13] *Jour. Amer. Med. Assoc.*, lvi, p. 1424, 1916.

to the narcotic action of alcohol on the cerebrum, partly to a stimulating effect upon the medulla, namely, on the vagus and the vasomotor centers, and partly to an improved nutrition of the heart as a consequence of dilatation of the coronary vessels. Clinically, small and moderate doses of alcohol produce a slight increase in blood pressure, a slight slowing of the heart beat, a vasodilatation of the peripheral vessels and diuresis. The action of alcohol upon the circulation is a rapid one, so that one of the cardinal therapeutic indications for its use is as a stimulant in collapse or shock.

From the toxicological point of view, alcohol, in respect to its action on the central nervous system, stands midway between hypnotics and general anesthetics. When taken in moderate doses, it is often conducive to sleep, while in larger doses it was commonly employed as an anesthetic for surgical operations before the discovery of ether and chloroform anesthesia. Furthermore, it is well known to every clinician, as well as pharmacologist, that small doses of alcohol often improve digestion, partly through a reflex action on the salivary and gastric secretions and partly through their psychic effects. Ethanol is quickly absorbed from the stomach and in sensitive subjects such absorption is rapidly followed by peripheral vasodilatation and flushing of the face and head.

The effects of alcoholic intoxication are too well known to be described. Acute alcoholism of the extreme type is characterized by delirium tremens and followed by coma and death. Chronic poisoning is manifested by a variety of symptoms and leads to degenerative changes in the nervous, cardiovascular and renal systems. Chronic congestion of the skin and mucous membranes and digestive disturbances are also very common in habitual alcoholics.

The principal therapeutic indications of alcohol may be summed up as follows:

(1) As a food, more particularly in fevers and certain constitutional diseases like diabetes.

(2) As a valuable stimulant in acute circulatory conditions.

(3) As a rapid and efficient stimulant in cases of collapse and shock.

(4) In small doses, as a useful agent in treatment of anorexia and certain forms of indigestion.

(5) As a vasodilator and diaphoretic in certain infections, such as coryza, grippe, etc.

(6) As a mild hypnotic in selected cases.

(7) As an invaluable sedative of the nervous system, promoting general relaxation and thus protecting against excessive nervous strain.

(8) As an analeptic agent in psychiatric conditions, more particularly melancholia and other depressive states.

Etymological Consideration[14]

The English world *alcohol,* as is well known, is of Semitic origin. It is an Arabic word, consisting of two parts, *al* and *koh'l, al* being the definite article and *koh'l* denoting a fine black powder, in reality a sulphide of antimony, or galena, obtained by sublimating antimonium compounds. Alcohol, in Arabic, thus meant originally a very fine product of sublimation. The powder was used by ladies as a cosmetic for penciling the eyebrows. Later, the term was applied to "distillate" or highly refined spirits, obtained from wine. The use of the same term for a sublimate and a distillate is, from a chemical point of view, not at all incongruous. In Spanish, the word alcohol still retains two meanings, the older one denoting a pigment or dye and the later one denoting alcohol proper.

Our colloquial term "booze" is, according to Berthold Laufer,[15] also partly

[14] *Cf.* Lexica of Gensenius, Fürst, Ben Yehuda, and Aruch Completum of Jastrow.

[15] *Jour. Amer. Med. Assoc.*, xlix, p. 56, 1929.

of Oriental origin. There is an old Persian-Arabic word, *bŏza* or *buza,* denoting an alcoholic beverage, made from millet, barley or rice, which is widely distributed over Asia, Europe and Northern Africa. This word, according to Laufer, is very possibly the same as our American *booze.*

The term alcohol is not found in the Old Testament, although it has been introduced into modern Hebrew. In the Bible, however, we find a wealth of terms denoting wine and other alcohol-containing liquors. The etymological significance of these is of great interest and is briefly considered in this place. *Yayin* is the term for wine most frequently occurring in the Hebrew Bible. It is always applied to wine made from grapes and not to other so-called wines, prepared from various fruits or berries. The etymology of this word, according to Rabbi S. R. Hirsch,[16] is probably from the Hebrew root *yanah,* which means *to oppress.* Thus, in Zephaniah iii: 1, we read *ha-'ir ha-yonah,* meaning *the oppressing city.* Again, in Jeremiah xlvi: 16 and l: 16, we find the expression *hereb yo-nah,* which may be rendered *the oppressive sword.* The term *to oppress* is, of course, figuratively identical with the physical word *to press* and in the case of another Hebrew root, *lahaṣ,* we find both meanings. Thus in Numbers xxii: 25 and II Kings vi: 32, the verb *lahaṣ* means *to press* or *squeeze,* while in Exodus iii: 9; xxiii: 9, and Judges i: 34, the same word is used in a sense of *oppressing.* The cognate root to *yayin* in Arabic, *yawan,* actually denotes *to press.* It is therefore quite obvious that the word *yayin* refers to the *expressed juice* of the grape.

The expression *grape juice,* or *blood of grapes,* as referring to wine, also occurs in the Old Testament. Thus, in Genesis xlix: 11, we read,

> He washeth his garments in wine (*yayin*), and in the *blood of grapes* his clothes.

and in Deuteronomy xxxii: 14,

> Of the *blood of the grape* thou drankest unmixed wine (*hŏmĕr*).

Another term for wine found in the Hebrew Bible is *tirôš.* This is usually applied to a stronger form of wine than *yayin* and may be translated *strong wine.* The root of *tirôš* is probably from the Hebrew *yārăš,* which means *to seize possession of* or *to inherit* and refers probably to the overpowering effects of alcohol on the head. According to Hirsch, *tirôš* may also come from the root *yārăš, to inherit,* denoting the inheritance, or the "leavings," of the grape after it has been squeezed. A popular derivation of the word *tirôš* is found in the Talmud (Yoma 76: b). Here we have a play on words of similar sound, one being *tirôš,* denoting *wine,* and the other *rŏš,* denoting *poverty.*

> The wise men say, "He who indulges in wine (*tirôš*) becometh poverty-stricken (*rŏš*)."

Still another term for an alcoholic liquor found in the Hebrew Bible is *šĕkhor,* generally translated *strong drink.* The same root gives the Hebrew word which denotes *drunkenness.* Hirsch calls attention to the phonetic relation between the roots *šĕkhor* and *šèquer,* the former denoting *strong drink* and the latter, *a lie,* and he points out the similarity of the two psychological states, drunkenness on the one hand, and distortion of truth, or lying, on the other. Philologically, however, the root *šĕkhor* is generally correlated with the root *šākhar,* meaning *to shut up* or *to be stopped up.* Thus, in Genesis viii: 2, we read,

> The fountains also of the deep, and the windows of heaven were *stopped* (*wayyi-šokhrû*).

And in Psalm lxiii: 12.

> The mouth of those that speak falsehood *shall be stopped.*

[16] "Kommentar zum Pentateuch," loc. Gen. ix. 21.

The idea of drunkenness here emphasized is that of the *stopping up* of the normal channels of reasoning. A further proof of the relation between *šĕkhor* and the root *śākhar* is that, in Isaiah xix: 10, the word *to stop up* is actually written with the letter *śin*. Some translations of this passage take the word *śākhar* from the root meaning *to hire* and read as follows,

> They that *earn wages* shall be grieved in soul.

In the new translation of the Jewish Publication Society, 1917, however, the denotation of *stopping up* is chosen as more appropriate and we read the following,

> All they that make *dams* shall be grieved in soul.

Still another word for wine found in the Bible is *hōmĕr*, really denoting *must* or *fermenting grape juice*, from the root *hāmár, to be in ferment* or to be *agitated*. Thus we find this word in Deuteronomy xxxii: 14,

> Thou drankest unmixed wine (*hōmĕr*).

And in Isaiah xxvii: 2,

> Sing ye a song of the vineyard of excellent wine (*hōmĕr*).

In addition to the meaning *fermentation*, the root *hamár* also signifies *to muddle*, and a noun, *hōmer*, derived from the same root, denotes *mud* or *mire*. Compare Isaiah x: 6 and Job xxx: 19:

> I give him a charge . . . to render them trodden down like the *mire* of the streets.—He hath cast me into the *mire*.

This idea of *muddling* is regarded by some as the basic significance of *hōmĕr, wine*, referring to the muddling or clouding of the mind by too much drink.

Two other words denoting wine are found in the Old Testament. These are *mésĕkh* and *méşĕg*, both from closely allied roots, each denoting *mixing*. These terms are applied not to pure wine but to *mixed* wine or wine which has been doctored with spices, etc. The word *méżĕg* occurs in Canticles vii: 3, in which we read,

> Thy navel is like a round goblet which lacketh not the mixed wine (*méżĕg*).

and the word *mésĕkh*, which also signifies a mixed or doctored drink, is found in Psalm lxxv: 9,

> The wine (*yayin*) foameth, it is full of mixture (*mésĕkh*).

Examination of Biblical Passages

(1) *Wine as Food*

The Hebrew Bible contains some two hundred passages referring to wine, strong drink and other alcoholic beverages. By far the largest number of such references speak of wine, or fermented grape juice, as an agricultural product universally utilized as food or harmless beverage. Still other numerous passages in the Old Testament mention wine in connection with sacrificial rites, as an offering symbolizing one of man's most cherished and valuable material possessions. It would require too much space to quote all such passages in reference to wine. The following, however, will serve as excellent examples, indicating the status of wine as food or daily beverage among the ancient Hebrews and other peoples mentioned in the Bible.

> And Melchizedek, king of Salem, brought forth bread and wine (*yayin*): and he was the priest of the most high God.—*Genesis xiv: 18.*

> Therefore God give thee of the dew of heaven, and the fatness of the earth, and plenty of corn and wine (*tirôš*).—*Genesis xxvii: 28.*

> And with the one lamb a tenth deal of flour mingled with the fourth part of an hin of beaten oil; and the fourth part of an hin of wine (*yayin*) for a drink offering.—*Exodus xxix: 40.*

> And the meat offering thereof shall be two tenth deals of fine flour mingled with oil, an offering made by fire unto the LORD for a sweet savour: and the drink offering thereof shall be of wine (*yayin*), the fourth part of an hin.—*Leviticus xxiii: 13.*

> And the fourth part of an hin of wine (*yayin*) for a drink offering shalt thou prepare

with the burnt offering or sacrifice, for one lamb.—*Numbers xv: 5.*

And He will love thee, and bless thee, and multiply thee: He will also bless the fruit of thy womb, and the fruit of thy land, thy corn, and thy wine (*tirôš*).—*Deuteronomy vii: 13.*

That I will give you the rain of your land in its due season, the first rain and the latter rain, that thou mayest gather in thy corn, and thy wine (*tirôš*), and thine oil.—*Deuteronomy xi: 14.*

And thou shalt bestow that money for whatsoever thy soul lusteth after, for oxen, or for sheep, or for wine (*yayin*), or for strong drink (*šēkhar*), or for whatsoever thy soul desireth: and thou shalt eat there before the LORD thy God, and thou shalt rejoice, thou, and thine household.—*Deuteronomy xiv: 26.*

Yet there is both straw and provender for our asses; and there is bread and wine (*yayin*) also for me, and for thy handmaid, and for the young man.—*Judges xix: 19.*

And when she had weaned him, she took him up with her, with three bullocks, and one ephah of flour, and a bottle of wine (*yayin*), and brought him unto the house of the LORD in Shiloh.—*I Samuel i: 24.*

And, behold, I will give to thy servants, the hewers that cut timber, twenty thousand measures of beaten wheat, and twenty thousand baths of wine (*yayin*), and twenty thousand baths of oil.—*II Chronicles ii: 9.*

Ho, every one that thirsteth, come ye to the waters, and he that hath no money; come ye, buy, and eat; yea, come, buy wine (*yayin*) and milk without money and without price.—*Isaiah lv: 1.*

Thou shalt sow, but thou shalt not reap; thou shalt tread the olives, but thou shalt not anoint thee with oil; and sweet wine (*tirôš*), but shalt not drink wine (*yayin*).—*Micah vi: 15.*

Now that which was prepared for me daily was one ox and six choice sheep; also fowls were prepared for me, and once in ten days store of all sorts of wine (*yayin*).—*Nehemiah v: 18.*

And I will bring again the captivity of my people of Israel, and they shall build the waste cities, and inhabit them; and they shall plant vineyards, and drink the wine (*yayin*) thereof; they shall also make gardens, and eat the fruit of them.—*Amos ix: 14.*

Until I come and take you away to a land like your own land, a land of corn and wine (*tirôš*), a land of bread and vineyards.—*Isaiah xxxvi: 17.*

And the earth shall respond to the corn, and the wine (*tirôš*), and the oil; and they shall respond to Jezreel.—*Hosea ii: 24.*

Yea, the LORD will answer and say unto His people, Behold, I will send you corn, and wine (*tirôš*), and oil, and ye shall be satisfied therewith.—*Joel ii: 19.*

Come, eat of my bread, and drink of the wine (*yayin*) which I have mingled.—*Proverbs ix: 5.*

And the king appointed them a daily provision of the king's meat, and of the wine (*yayin*) which he drank.—*Daniel i: 5.*

Go thy way, eat thy bread with joy, and drink thy wine (*yayin*) with a merry heart; for God now accepteth thy works.—*Ecclesiastes ix: 7.*

(2) *Wine as a Heart Stimulant*

One of the most important therapeutic indications for administration of alcohol in medical practice is in circulatory collapse, or syncope, in which cases its rapidly stimulating effects may be life-saving. While the exact mechanism of its action in such cases is a complicated one, as already discussed in the pharmacological section, the favorable results of alcoholic stimulation in such acute cardiac and other circulatory conditions are recognized by all physicians. How tersely, yet accurately, is this fact described in the Psalms! Here we read (Psalm civ: 15),

Wine *cheereth*—that is, stimulates—the heart of feeble man (*'enoš*).

The word *sāmah, to cheer,* is closely related, according to the rabbis, to the root *sāmah, to sprout* or *blossom.* Wine stimulates or brings fresh energy and makes blossom the exhausted heart. The Psalmist warns us, however, that such a stimulation is but transient and that the real source of the heart's strength must be proper food,

But it is bread which giveth *sustenance* to a man's heart.

Every pathologist is well aware that two of the most important causes of myocarditis, or degeneration of the heart muscle, are alcohol and syphilis. Excesses *in Baccho et Venere* are responsible for numerous deaths from heart disease. In Hosea (iv: 11), a single line states with marvelous scientific insight

these two most important etiological factors of myocardial degeneration,

Whoredom and wine and new wine take away the heart.

A third vice conducive to degeneration of the arteries and weakening of the heart is often classed with the two preceding, namely, gluttony. In this connection, compare Proverbs xxiii: 20,

Be not among winebibbers: among riotous eaters of flesh.

The well-known association of alcohol and dissipation is succinctly stated in the Midrash (Bamidbor Rabba 10: 3),

Wherever there is drunkenness, there is also incest.

The description of Nabal's illness and death, given in I Samuel xxv: 36–38, is of considerable pathological interest. We read that this individual was addicted to excessive drinking to the extent of becoming unconscious. Such repeated excesses evidently affected his heart and blood vessels, for an acute emotional crisis brought on an apoplectic stroke and death. The following is the Biblical account:

And Abigail came to Nabal; and, behold, he held a feast in his house, like the feast of a king; and Nabal's heart was merry within him, for he was very drunken: wherefore she told him nothing, less or more, until the morning

But it came to pass in the morning, when the wine was gone out of Nabal, and his wife had told him these things, that *his heart died within him, and he became as a stone.*

And it came to pass about ten days after, that the LORD smote Nabal, that he died.

(3) *Exhaustion and Shock*

The beneficial effects of wine and alcohol in shock and other states of great exhaustion were well known in ancient times. The following passages in the Bible give proof of this:

Give strong drink unto him that is about to perish.—*Proverbs xxxi: 6.*

They say to their mothers, Where is corn and wine? when they swooned as the wounded in the streets of the city.—*Lamentations ii: 12.*

The king said unto Ziba, What meanest thou by these? And Ziba said, The asses be for the king's household to ride on; and the bread and summer fruit for the young men to eat; and the wine, that such as be faint in the wilderness may drink.—*II Samuel xvi: 2.*

(4) *Effects on the Nervous System*

Ethyl alcohol, in common with all alcohols, exerts its principal pharmacological action on the central nervous system. It is therefore gratifying to find that many of the passages referring to wine and alcoholic liquors in the Hebrew Bible dwell in particular on the various neurological and psychological effects of drinking.

The striking *loss of motor coordination*, or staggering, produced by alcohol, is vividly pictured in Psalm lx: 5:

Thou hast made Thy people to see hard things; Thou hast made us to drink the wine (*yayin*) of staggering.

Again, in Isaiah xxix: 9, we read:

Stupefy yourselves, and be stupid! Blind yourselves, and be blind! ye that are drunken, but not with wine (*yayin*), that stagger, but not with strong drink (*šēkhor*).

The *hypnotic and anesthetic effects* of liquor are mentioned in Genesis xix: 32, 33:

Come, let us make our father drink wine (*yayin*), and we will lie with him, that we may preserve seed of our father.

And they made their father drink wine (*yayin*) that night . . . and he knew not when she lay down, nor when she arose.

The deep sleep produced by wine is also indicated by the story of Noah, Genesis ix: 24:

And Noah awoke from his wine (*yayin*), and learned what his younger son had done unto him.

The story of Noah and his vineyard is a direct refutation of the alien

thoughts read into the Bible by those who assert that the wine of the Old Testament was not alcoholic. Noah not only drank wine, but also became intoxicated and, furthermore, gave an excellent demonstration of the sleep-producing potency of liquor (Genesis ix: 20, 21, 22, 24):

> And Noah began to be an husbandman, and he planted a vineyard:
> And he drank of the wine (*yayin*), and was drunken; and he was uncovered within his tent.
> And Ham, the father of Canaan, saw the nakedness of his father, and told his two brethren without. . . .
> And Noah awoke from his wine (*yayin*), and learned what his younger son had done unto him.

The ancient Hebrews, in common with other nations of antiquity, employed alcohol for deadening pain just as anesthetics are employed to-day. Pharmacologically large doses of alcohol deaden the pain areas in the cerebrum and produce unconsciousness, or general anesthesia, like ether and chloroform. This property was made use of in connection with capital punishment. The Hebrews inflicted the death penalty when warranted by the nature of the crime committed, but in all cases it was considered a duty to render the infliction of death in a merciful and painless manner. For this reason, the condemned were made to drink large quantities of liquor or strong wine, which were often also mixed with various narcotics. Thus, in the Talmud (Sanhedrin 43 a), we learn that when a person was about to be put to death, he was given to drink a cup of wine with a dose of *lebônah*. Again, in the Midrash Rabba (Shemoth Rabba 84), we find a statement that all those doomed to capital punishment were given wine to drink that they might not suffer. It is interesting to note that certain passages in the Old Testament also refer to this custom. Thus, in Amos ii: 8, we read:

> And they lay themselves down upon clothes laid to pledge by every altar, and they drink the wine (*yayin*) of the condemned in the house of their god.

One of the most important and undisputed therapeutic effects of alcoholic beverages is in certain *psychiatric conditions* characterized by depression, such as melancholia, etc. In this connection, the famous passage in Proverbs xxxi: 6, 7, is of special interest:

> Give strong drink (*šēkhor*) unto him that is about to perish, and wine (*yayin*) unto the bitter in soul.
> Let him drink, and forget his poverty, and remember his misery no more.

The stimulating effects of wine in depressive states are also described in Ecclesiastes x: 19:

> A feast is made for laughter, and wine (*yayin*) maketh glad the life.

In discussing the cerebral effects of alcohol in the pharmacological section of this paper, mention was made of the moot question in regard to the stimulating effects of alcohol on the brain. It was pointed out that, according to the Binz school, small doses produced a true primary stimulation of the nervous elements, whereas, according to Schmiedeberg and his school, such a stimulation was really due to a release of inhibitions. Several passages in the Hebrew Bible hint at the pseudo-stimulation produced by alcohol. Thus, in Proverbs xx: 1, we read,

> Wine (*yayin*) is a mocker, strong drink (*šēkhor*) is raging; and whosoever is *deceived* thereby is not wise.

The loss of self-control, the boastfulness, recklessness and display of emotionalism after excessive drink are but too well known. Many passages in the Bible refer to such states. Thus, in Habakkuk ii: 5, we find this description,

> He transgresseth by wine (*yayin*), he is a proud man.

Again, in Isaiah v: 22 and xxii: 13, we read:

Woe unto them that are mighty to drink wine (*yayin*), and men of strength to mingle strong drink (*šēkhar*).

And behold joy and gladness, slaying oxen, and killing sheep, eating flesh, and drinking wine (*yayin*); let us eat and drink, for to-morrow we shall die.

While wine and alcohol have their proper place in therapeutics in stimulating the spirits of the depressed and hypochondriac, the Bible clearly indicates, in agreement with the latest findings of experimental psychology, such as those of Kraepelin, Benedict and others, that the imbibition of alcoholic beverages is not conducive to very accurate psychological performance, either in the neuro-muscular sphere or in the higher intellectual processes of the cerebrum. It is interesting to note that the drinking of wine or liquor is *prohibited to leaders* in Israel, whether legislative or judicial or executive or purely religious, during the performance of their respective duties or tasks. In Leviticus (x: 9) is an injunction given to the *priests* not to partake of wine or strong drink when going into the tabernacle of the congregation for the performance of religious rites.

Do not drink wine (*yayin*) nor strong drink (*šēkhar*), thou, nor thy sons with thee, when ye go into the tabernacle of the congregation, lest ye die: it shall be a statute for ever throughout your generations.

Again, in Ezekiel xliv: 21, we read:

Neither shall any priest drink wine (*yayin*) when they enter into the inner court.

The king, whose name, according to a beautiful Hebrew legend, is a mnemonic of his duties, is also warned to abstain from alcoholic excesses. The Hebrew word for king, *MeLeK*, consists of three consonants, M, L and K. Each of these letters, according to the Rabbis, is the abbreviation of a preposition: M, standing for *min*, denotes *from*; L is the Hebrew preposition *to*; and K is the comparative particle, meaning *as* or *like*. The Hebrew ideal of a king was that of an exalted paragon, a personage *from whom* authority came, to *whom* every one appealed for justice and a noble character *like whom* his subjects should try to be. In order to perform his functions most faithfully, it is well for the king not to drink.

It is not for kings, O Lemuel, it is not for kings to drink wine (*yayin*); nor for princes strong drink (*šēkhar*).—*Proverbs xxi: 4.*

Isaiah denounces the priests and the *prophets*, teachers of the people and their spiritual leaders, for erring in judgment and other duties through their devotion to drink.

But they also have erred through wine (*yayin*), and through strong drink (*šēkhar*) are out of the way; the priest and the prophet have erred through strong drink (*šēkhar*), they are swallowed up of wine (*yayin*), they are out of the way through strong drink (*šēkhar*); they err in vision, they stumble in judgment.—*Isaiah xxviii: 7.*

(5) *Toxicological Phenomena*

A wealth of information is to be gleaned from the Old Testament concerning both milder forms and extreme manifestations of alcoholic intoxication.

The congestive and inflammatory effects of habitual drink are described in Isaiah v: 11:

Woe unto them that rise up early in the morning, that they may follow strong drink (*šēkhar*); that continue until night, till wine (*yayin*) inflame them!

Exaggerated self-confidence and boastfulness are described in Isaiah v: 22:

Woe unto them that are mighty to drink wine (*yayin*), and men of strength to mingle strong drink (*šēkhar*).

and again in Habukkuk ii: 5,

He transgresseth by wine (*yayin*), he is a proud man.

Garrulousness and loud talk are mentioned in Zechariah ix: 15:

They shall drink, and make a noise as through wine (*yayin*); and they shall be filled like bowls, and as the corners of the altar.

Inflammation of the mucous membranes, more particularly, of the eyes, is cited in Genesis xlix: 12,

His eyes shall be red with wine (*yayin*), and his teeth white with milk.

The revolting picture of the tippler's gastritis is strongly depicted in Jeremiah xxv: 27 and xlviii: 26:

Drink ye, and become drunken, and vomit, and fall, and rise no more.

Make him drunken; for he magnified himself against the LORD; and Moab shall wallow in his vomit and he also shall become an object of derision.

The deteriorating effects on the vision, as well as on the brain, are mentioned in Isaiah xxix: 9:

Blind yourselves, and be blind! ye that are drunken.

Two verses from the prophets are of unusual interest because of their vivid description of the extreme and acute alcoholic intoxication. To appreciate these, a careful study and accurate translation of the original text are necessary. Jeremiah li: 39, in the authorized version, is translated thus:

In their heat I will make their feasts, and I will make them drunken, that they may rejoice, and sleep a perpetual sleep, and not wake, saith the LORD.

The widely used Jewish translation by Leeser gives practically the same interpretation with perhaps a slightly clearer meaning:

When they are heated will I prepare their drinking-feasts, and I will make them drunken, in order that they may be joyful, and sleep a perpetual sleep, and not awake again, saith the LORD.

This verse, however, in the light of the most recent philological researches is more correctly and appropriately to be construed as follows: The Hebrew *b'hummam,* ordinarily rendered as *in their heat,* can be equally well derived from the root *hemah,* meaning *poison,* and the verb *ya'alozu,* ordinarily taken from the root *'alaz, to rejoice,* may be interpreted, according to another Massoretic reading, as coming from the root *'alaf,* meaning *to tremble.*[17] The sense of the passage is therefore as given by the latest translation, published under the auspices of the Jewish Publication Society:[18]

With their *poison* I will prepare their feast, and I will make them drunken, that they may be *convulsed,* and sleep a perpetual sleep, and not wake, saith the LORD.

Here we have a graphic description of delirium tremens, or convulsions, induced by excessive quantities of alcohol, which are followed by coma and death.

Another passage describing the coma induced by alcoholic intoxication of extreme degree is to be found in Nahum iii: 11. Here the verb root *'alam,* rendered in the authorized version *to be hidden,* has also in Hebrew the well-substantiated meaning of *fainting* or *swooning,* which gives a much more grammatical and pharmacologically more appropriate translation:

Thou also shalt be drunken, thou shalt *swoon*; thou also shalt seek a refuge because of the enemy.

(6) *Proverbs xxiii: 29–35*

This passage in the Book of Proverbs is a classical description of the psychological and pharmacological effects of excessive alcoholic drinking and deserves a more detailed examination on that account. Certain portions of this description, as given in most translations of the Bible, are remarkably obscure and almost incomprehensible. A careful study of the Hebrew text, however, in the light of both physiological and phar-

17 Kittel, Edition of Hebrew Bible.

18 New English Trans. Hebrew Bible, Philadelphia, 1917.

macological investigation, proves it to be of even greater interest than was ordinarily supposed. The late Professor Paul Haupt has called attention to several difficulties encountered in the translation of these verses in a paper, published in the *Journal of Biblical Literature,* which was intended to expose the fallacy of certain individuals who attempted to prove that wine referred to in the Bible was non-alcoholic, and some of his Hebrew renditions are extremely enlightening.[19]

29 Who hath woe? who hath sorrow?
Who hath contentions? who hath babbling?
Who hath wounds without cause?
Who hath redness of eyes?
30 They that tarry long at the wine;
They that go to seek mixed wine.
31 Look not thou upon the wine when it is red,
When it giveth his colour in the cup,
When it moveth itself aright.
32 At the last it biteth like a serpent,
And stingeth like an adder.
33 Thine eyes shall behold strange women
And thine heart shall utter perverse things.
34 Yea, thou shalt be as one that lieth down in the midst of the sea,
Or as he that lieth upon the top of a mast.
35 They have stricken me, *shalt thou say,* and I was not sick;
They have beaten me, and I felt *it* not:
When shall I awake?
I will seek it yet again.

The most interesting part of this quotation is verse 34, yet it is difficult to make common sense of the English as given above. What is meant by "lying down in the midst of the sea," and still more, how can one "lie upon the top of a mast"? The first question can be easily answered. Professor Haupt calls attention to the fact that the Hebrew expression *leb yam,* the *heart of the sea,* expresses figuratively the *bosom of the sea,* that is, the waves of the high sea. The correct translation is therefore, *as one that is sailing on high seas* and consequently nauseated, dizzy and seasick. The Hebrew expression *šôkeb be-rôš ḥibbêl,* rendered as "lying on the top of a mast," is even more mystifying. The Hebrew word *rôš,* meaning *head,* has been shown by Professor Haupt to refer in this passage to opium.[20] The powerful alkaloids of opium are obtained by incisions around the *caputa,* or *heads,* of the poppy, *Papaver somniferum,* and the Hebrew word *rôš,* or *head,* in this verse most likely denotes the narcotic poppy head. In the Old Testament, *rôš,* the bitter poison of the poppy head, is repeatedly mentioned in connection with *la'anah, wormwood* or *absinthe* (Jeremiah viii: 14; ix: 15, etc.). Again, the expression *mê rôš* is appropriately translated as *juice of the poppy head.* We have already remarked that the Talmud relates that a cup of wine with *lebônah* was given to criminals before their execution. The word *lebônah,* although ordinarily applied to one of the ingredients of incense, is also used in general for a bitter aromatic drug such as opium.

As regards the word *ḥibbêl,* rendered as *mast,* an entirely different translation, more correct philologically and certainly more appropriate pharmacologically, can be given. The word *ḥibbêl* can be grammatically written *ḥobel,* a present participle from the root *ḥābal,* meaning *to bruise, injure, knock out, destroy.* The expression *rôš ḥôbēl,* therefore, means literally the "knock-out" or *injurious poppy* and refers to the stupefying or narcotic effects of opium. Compare the slang expression, "knock-out drops," applied to the powerful hypnotic *chloral.* The author of the Proverbs wishes to convey the idea that an excessive dose of alcohol produces a drunken stupor much like the narcotic effect or stupor of opium or dope. The translation by Professor Haupt vividly sketches the salient features of acute and habitual alcoholism, emphasizing at the same time the similarity of action between alcohol

[19] Haupt, *Jour. Biblical Lit.,* xxxv, p. 75, 1917.

[20] Haupt, *Proc. Amer. Philosoph. Soc.,* April 25, 1915.

and various narcotic drugs. This is exactly in accord with the most modern views of pharmacologists. The narcotics (opium), the hypnotics (chloral), and the general anesthetics (ether and chloroform) are pharmacologically all drugs belonging to one class, the great group of compounds acting primarily upon the brain and central nervous system. Professor Haupt's translation of the lines before us is a grammatically accurate one and, pharmacologically, an astoundingly true and vivid one.

29 Who has woe? and who has misery?
Who has brawls? and who has grief?
Who has wounds without any cause?
And who has dimness of eyes?
30 Those who linger long o'er the wine,
Who come to try the mixture.
31 Look not on the wine that is red,
When it gives its gleam in the cup;
32 It glides down smoothly, but at last
It is like a viper that stings.
33 Thine eyes will see strange things,
Thy heart will blab queer things;
34 Thou'lt feel as one sailing the high seas
Or as one put to sleep by poppy.
35 If they hit me, I was not sore;
If they struck me, I did not feel it.
As soon as I wake from my wine,
I shall surely try it again.

Comment

From the standpoint of modern pharmacology, a critical examination of the numerous Biblical passages cited above leads to some very interesting and delightfully refreshing conclusions. We find in the Hebrew Bible an extraordinarily well-balanced and scientifically up-to-date and complete account of the various physiological, pharmacological and toxicological properties of ethyl alcohol.

Alcoholic beverages in moderation are, strictly physiologically speaking, of some value as *foods*, and the Old Testament affords abundant proof of their having been regarded as such by the ancient Hebrews.

Wine and alcohol, from the standpoint of modern pharmacology, are of unquestionable value as a *medicament* in a series of clinical and pathological conditions, the most important of which are shock, cardiac failure, insomnia, nervous exhaustion and mental depression. The beneficial effects of wine and strong drink, when taken in moderation, for each and every one of these conditions, are unequivocally attested in the Hebrew text. If the modern pharmacologist and practicing physician would include under its medicinal applications the employment of alcohol *pharmaceutically*, as for the extraction and preparation of drugs, for which purpose it has always been indispensable from remote antiquity to the present time, we should fully agree with the epigrammatic dictum of the Talmud, which apostrophizes as follows:

> I, alcohol, am at the head of all medicaments.
> —*Baba Bathra 58, b.*

The dangers of abuse and of excessive drink, however, are just as emphatically described in the Bible as are its medicinal values, and the descriptions of alcoholic poisoning of all degrees have been shown to be unsurpassed in their accuracy and forcefulness. The danger of alcoholic excesses, according to the Book of Books, does not result in the absolute prohibition of the use of alcohol, no more than that of other drugs. The writer, as a pharmacologist, can not refrain from quoting an apt expression frequently employed by his distinguished teacher, Professor John J. Abel, who in his lectures used to say, "The molecule of C_2H_5OH is not distinguished from molecules of other drugs or therapeutic agents by a distinctive and peculiar poison label." All drugs are also poisons. How a given drug will act, whether as a medicament or harmful agent, will depend on dosage, on the patient or subject taking it and on numerous other conditions.[21] Ethyl

[21] Macht, *The Maryland Pharmacist*, p. 187, 1927.

alcohol, or grain alcohol, is but a single member of a large series of chemical compounds known as alcohols, the vast majority of which are very much more poisonous and harmful. In a purely scientific investigation, the author has shown elsewhere that all alcohols of the fatty acid series are intoxicating and their toxicity increases with their molecular weight, with the exception of methanol, or wood alcohol, which, while being lower than ethyl alcohol in the chemical series, is of an especially poisonous nature owing to the formation of destructive compounds in the animal body when it is taken internally.[22] On the other hand, ethyl alcohol is exceptional in its low toxicity because a certain amount of it can be burned up in the body and utilized as a food.[23] An even more remarkable phenomenon has been demonstrated recently by Macht and Leach, who have shown that small doses of wood alcohol combined with grain alcohol produce a mixture which is even more poisonous than methanol in pure form.[24] Macht and Ting[25] have also demonstrated experimentally that even the so-called polyhydric alcohols, such as glycol, glycerine and even the solid mannitol, are, pharmacologically speaking, intoxicating and differ in their narcotic effects from ordinary alcohol and from each other only in respect to dosage. The writer and his coworkers[26] have further demonstrated, in a comparative study of alcohol, caffeine and nicotine, administered in minute doses, comparable to the amounts of these substances taken by human beings in their every-day beverages and in moderate smoking of tobacco, that of the three chemical substances of drugs thus ingested or absorbed the *nicotine was by far the most poisonous.* Next in order came caffeine, and *alcohol was the least harmful.* Such scientific data in regard to alcohol are strikingly in accord with the accounts of its action on man described repeatedly in the universally revered and fascinating literary text before us. The status of fermented grape juice and strong drink, as given in the Bible, may perhaps be most appropriately summarized by two quotations from the text.

> The trees went forth to anoint a king over them: and they said unto the olive tree, Reign thou over us.
>
> But the olive tree said unto them, Should I leave my fatness, wherewith by me they honour God and man, and go to be promoted over the trees?
>
> And the trees said to the fig tree, Come thou, reign over us.
>
> But the fig tree said unto them, Should I forsake my sweetness, and my good fruit, and go to be promoted over the trees?
>
> Then said the trees unto the vine, Come thou, reign over us.
>
> And the vine said unto them, Should I leave my *wine, which cheereth God and man,* and go to be promoted over the trees?—*Judges ix: 8–13.*

> Thus saith the LORD, As the new wine is found in the cluster, and one saith, *Destroy it not; for a blessing is in it:* so will I do for my servants' sakes, that I may not destroy them all.—*Isaiah lxv: 8.*

A pharmacological appreciation of Biblical allusions to alcohol leads us to but a single logical conclusion: the Book of Books is in complete accord with the most modern and advanced experimental data on the subject.

[22] Macht, *Jour. Pharm. and Exper. Therap.,* xvi, No. 1, p. 1, 1920.

[23] Macht, *American Druggist,* lxxix, No. 3, p. 12, 1929.

[24] Macht and Leach, *Proc. Soc. for Exper. Biol. and Med.,* xxvi, p. 330, 1929.

[25] Macht and Ting, *Amer. Jour. Physiol.,* lx, No. 3, p. 496, 1922.

[26] Macht, Bloom and Ting, *Amer. Jour. Physiol.,* lvi, No. 2, p. 264, 1921.

ON SOME PHASES OF PREVENTIVE ENTOMOLOGY

By Professor HARRY S. SMITH
UNIVERSITY OF CALIFORNIA, CITRUS EXPERIMENT STATION

One often hears the expression that "most of our major insect pests are of foreign origin," but so far as the writer has been able to learn, actual data bearing on this subject have not been compiled in recent years. Thirty-two years ago Dr. L. O. Howard, in an interesting paper entitled "The Spread of Land Species by the Agency of Man,"[1] discussed the interchange of species between countries, with special reference to insects, and pointed out that of the seventy-three species considered by him to be at that time of prime economic importance, thirty were native to the United States, thirty-seven species had been introduced from foreign countries and six were of doubtful origin. Since that time several pests of great economic importance have found their way to the North American continent, and perhaps some of our own native insects, for one reason or another, have become changed in status in such a way as to require their classification with the pests.

In recent years entomologists have been paying increasing attention to two phases of their profession: quarantine work and the control of pests by the biological method. In both these branches of economic entomology the origin and distribution of plant-feeding insects is of great interest and of fundamental importance. Not long ago the writer had occasion to look into this question, and it was thought that perhaps some of the data secured might be of interest to others.

It is extremely difficult, as I am sure every one recognizes, to determine just what insect pests should and which should not be considered of prime economic importance.

I have started with the assumption that only insects of economic importance are discussed in the various text-books of economic entomology now available. In a few instances I have eliminated insects of obviously minor importance and of restricted distribution, included in these works because of special interest to the author. I have added a few important insect pests found in the western states, such as the black scale, citrophilus mealybug and beet leaf hopper, not generally referred to in text-books. The list so selected was then checked against the Index of Economic Entomology, all those having less than ten references being eliminated. The list thus decided upon I believe may be considered as representing the consensus of opinion of American entomologists as to which insects are of economic importance. Only insects destructive to plants and plant products are included.

By this method a list of 183 species was obtained of which 81 are of undoubted foreign origin, a total of 44.2 per cent. Of the remaining 102 species it is entirely probable that some are of foreign origin. I have made no attempt to consult the latest taxonomic works and it is possible that some of the species designated as native have already been determined by systematists to be of foreign origin, these determinations not yet having found their way into economic literature. The figure indicating that of all insects of economic importance in America 44.2 per cent. are of

[1] *Proc. Am. Ass. Adv. Science*, XLVI, 1897.

foreign origin is, I believe, conservative, and will undoubtedly be enlarged as further studies on geographical distribution are made. Since I am including the entire North American continent instead of the United States proper, that most destructive of pests, the cotton boll weevil, falls in the "native" category. This I have done because it seemed desirable to distinguish between the invasion of pests through commercial exchange and invasion through natural spread brought about, as in the case of the cotton boll weevil, through extension by man of the culture of the host plant in such a way as to bridge the natural barrier to distribution. Such an invasion, from an ecological view-point, does not differ from the spread of a native species within the confines of the United States as exemplified by the potato beetle.

Of the seven orders in which the 183 species of insect pests fall, the Hemiptera have the honor of ranking first in number of species, there being fifty-four in this group, of which twenty-three are introduced and thirty-one are native. Ranking next to the Hemiptera are the Lepidoptera with fifty species, of which twenty-three are introduced and twenty-seven are native. Following in order of numbers are the Coleoptera with forty-two species, of which nineteen are introduced and twenty-three are native; the Diptera with eleven, of which five are introduced and six are native; the Hymenoptera with eight, of which four are introduced and four are native; the Orthoptera with seven, all of which are native, and the Thysanoptera with six, of which two are introduced and four are native. As previously stated, many of the species designated as native would more properly be considered as of doubtful origin.

Taking the *number* of introduced species, the Hemiptera and Lepidoptera tie for first place with twenty-three species each, followed by Coleoptera with twelve, Diptera with five, Hymenoptera with four, Thysanoptera with two and Orthoptera with none.

In *percentage* of introduced to total number of species of that order classed as pests, the ranking is as follows: Hymenoptera, 50 per cent.; Lepidoptera, 46 per cent.; Diptera, 45.4 per cent.; Coleoptera, 42.5 per cent.; Hemiptera, 42.5 per cent.; Thysanoptera, 33.3 per cent., and Orthoptera with none. While the writer admits that this ranking may be questioned because of the somewhat arbitrary method of selecting the species, these figures provide a basis for some interesting speculation.

The frequency of transportation of insects from one country to another should be directly proportional to the adaptability of the species to carriage through the channels of commerce; and the frequency of establishment should be proportional to their adaptability to the environment in which they find themselves when they reach their destination. The frequency of successful introductions of foreign insects should, therefore, be proportional to the degree with which these two requirements are met. It is of interest to look into this question and see if the facts fit the theory.

All the important Hymenoptera in this list of agricultural pests are sawflies. These insects, because of the habit of deferred emergence from cocoons frequently found in this family, are particularly well adapted to successful transportation through plant shipments. Some species spin their cocoons on the twigs and leaves of conifers and are easily transported in this way. Others, like the pear slug, spin their cocoons in the soil, and these would seem less likely to be transported, although they might easily come in in soil surrounding balled ornamentals grown between the rows of fruit trees, as is often done in districts of intensive cultivation. After having

been brought to America in some such way as mentioned, what are the possibilities of their becoming permanently established? Arriving on living plants, or in soil containing living plants which are to be planted out, conditions would seem to be ideal for their colonization, so far as environmental factors are concerned. But the one factor which makes for their successful establishment and which transcends all others in importance is their ability to reproduce parthenogenetically. Many species of sawflies have this faculty, and most of them are thelyotokous, regularly producing female progeny only, for generation after generation, without fertilization. In fact, in many species males are entirely unknown or are very rarely encountered.

It is undoubtedly a fact that one thing which operates strongly against the successful establishment of introduced species is lack of fertilization of the females. Most insects seem to have a strongly developed instinct to disperse soon after eclosion takes place, and for this reason the chances are much against their meeting individuals of the opposite sex when they find themselves in a new environment. Thelyotokous insects are not confronted with this difficulty, since a single female can successfully establish a colony. The surprising thing is that we do not have more sawfly pests of foreign origin.

The introduced Lepidoptera present such a variety of habits which have a bearing on their successful transportation and establishment that it is difficult to assign any special reason for their apparent success in this direction. Of the twenty-three introduced species in the list three are practically cosmopolitan pests of stored products, the Indian meal moth, the Mediterranean flour moth and the Anguomois grain moth. It is not necessary to look far for the reason for their cosmopolitan distribution. The gipsy moth was brought to this country purposely but its establishment was an accident. In view of its habits it is rather surprising that there have not been more of the so-called "commercial jumps" in this species. While it generally lays its eggs on large trees they are occasionally found on nursery stock and Christmas trees and even on lumber, stone, etc. The eggs are viable for several months after deposition and when they are deposited on nursery stock there would seem to be an excellent opportunity for establishment, particularly in view of the large number of eggs in a mass and in view of the fact that the females do not fly and could not, therefore, stray far from the center of infestation and fertilization thus be inhibited. For many years the federal government has maintained a quarantine on the infested area but I believe this has not always been the case.

The browntail moth was undoubtedly introduced on nursery stock in the winter webs and has been intercepted from Europe many times since it became established. The conspicuousness of its hibernating web makes it easy for inspectors to detect it. This has probably been the factor which prevented "commercial jumps" in this country. Its gregarious habits should make it a species which could easily become established.

The codling moth, by reason of the habit of the larva of crawling into the crevices of apple boxes or into almost anything else where it finds shelter, has become almost cosmopolitan. Although its habits do not seem to have any features which make it especially adapted to establishing colonies in a new region, the frequency with which it is transported together with the difficulty of controlling its spread by quarantine methods is responsible for its wide distribution.

The peach twig-borer, *Anarsia lineatella*, does not seem to be especially well

qualified for establishment in a new region, but this failing, as in the case of the codling moth, is counterbalanced by the ease and frequency with which it is transported on account of its habit of spending the winter in the crotches of dormant nursery stock. It is also, of course, difficult to detect by inspection and must often be overlooked.

Boring moths, such as *Diatrea*, *Zeuzera pyrina*, *Pyrausta nubilalis* and *Sesia tipuliformis*, are especially well qualified for introduction, since inspection for insects of this type is impractical, and coming in on living plants used for propagation, they find conditions ideal for establishment when they reach their destination.

Among the Diptera the outstanding introduced pest is, of course, the Hessian fly, supposed to have entered this country in grain straw during revolutionary times. Of the method of gaining entrance there can be little question, since it is difficult to imagine any other means by which insects of habits similar to this fly could be successfully transported to any great distance. Most of the other Dipterous pests in the list are Phorbias, or Pegomyias, which spend the winter either as larvae or puparia in the soil. Any shipment of soil from infested districts might serve to carry these insects to new localities. The box leaf-miner is, of course, ideally situated for transportation and establishment purposes, and it is surprising that this pest has not become more wide-spread. I have known of only one infestation in California, but that was severe, showing that the pest thrives under our climatic conditions.

Coleoptera, like the Lepidoptera, are of such varying habits that it is difficult to point to anything in particular to explain their successful establishment in this country. There are many species of beetles infesting stored products, such as the Bruchids and Calandras, whose habits fit them so well for transportation and establishment that they have become cosmopolitan in distribution.

The grape root-worm, *Adoxus obscurus*, may be circumpolar, but if not it was undoubtedly introduced in soil. This beetle, like the sawflies, is thelyotokous, female progeny being produced parthenogenetically, the males being extremely rare. The grape root-worm has become widely distributed on both the Eurasian and North American continents, probably as a result of this method of reproduction.

The introduction of the alfalfa weevil is rather difficult to account for, since it seems to have no habits which fit it particularly well either for transportation or for establishment. The adult weevils crawl into hay, straw or rubbish for hibernation, and it may have entered this country in that manner. The adult female beetles are fertile when they go into winter quarters and the importation of a few hibernating adults, if they escaped into an alfalfa field, might be sufficient to establish a colony. Once established in this country it is not difficult to account for its spread, since in California as many as eighty-two live adult weevils have been taken from a single camp outfit, the owners of which spent the night in the infested region of Reno, Nevada.

Scolytus rugulosus was undoubtedly introduced in nursery stock, and the sweet potato weevil in sweet potato tubers.

It is interesting to note that we have received from foreign countries practically no large wood-boring beetles of the families *Cerambycidae* and *Buprestidae*. The habits of these beetles would seem to fit them particularly well for transportation on nursery stock. Their failure to become established may be attributed to the fact that they occur in nursery stock only in small numbers, generally one to a tree, and the sexes are unlikely to emerge simultaneously. An exception

to this is *Agrilus sinuatus*, established in eastern United States.

In the order Hemiptera we find the insects which, above all others, are equipped for introduction and establishment in new regions. I believe it is safe to say that there are more cosmopolitan insects among the Coccidae and Aleyrodidae than in any other group of similar size. The reason for this is sufficiently plain. By their mode of life, firmly fixed as they are to their host plants, which as nursery stock or ornamentals for propagation purposes find wide commercial distribution throughout the world, they are better fitted for transportation than any other group. In addition to this many of them are thelyotokous, and thus a single female, finding herself on the same host plant upon which she developed in her native land, is able to establish a successful colony. We should expect this admirable adaptability to both transportation and establishment to have just the effect that it has in fact had. Inspection is not a safeguard against these insects since, particularly in the younger stages, they may secrete themselves under bark or bud scales. The Aphididae are almost equally well adapted to transportation, for, while they are not firmly fixed to their host plant like the scales, most of them deposit a tough-shelled hibernating egg well qualified to carry the species long distances under adverse conditions. Once arriving at their destination they are quite as well fitted for establishment as the Coccidae. The overwintering eggs produce a female which gives birth to living young without fertilization, and these do the same for generation after generation. It is surprising that more species of Aphididae are not recognized as cosmopolitan, and future studies by taxonomists will undoubtedly show that more of our aphid pests are of foreign origin than the records now indicate. Aside from these three families, only a relatively small proportion of the hemipterous pests in the list are introduced species, these being the pear Psylla and the tarnished plant bug, both of which probably entered the country as overwintering adults.

The Thysanoptera hibernate both as adults in sheltered places and as nymphs in the soil, and may easily be transported under either condition. *Heliothrips fasciatus* is often found hibernating in the navel ends of oranges, although it does not attack this fruit. It is supposedly native but other species have similar habits. The pear thrips spends the winter in the soil in great numbers in infested orchards and could easily have been brought in in this way. So far as establishment is concerned, several species reproduce parthenogenetically. This is notably true of the green-house thrips, the male of which has never been discovered. This is apparently not true, however, of two of our most serious introduced species, the onion thrips and the pear thrips.

Among the Orthoptera I have not come across any records of the introduction of foreign species which have become agricultural pests, although they may exist. *A priori* it may be assumed that their transportation through commercial exchange would be extremely unlikely. Grasshoppers usually deposit their eggs in the soil, it is true, but as a general rule they prefer either sod land or extremely hard soil, such as one would be unlikely to find in European nurseries and which would hardly be found in shipments of balled nursery stock. Tree crickets and katydids deposit their eggs in twigs and on leaves, and these are better equipped for transportation to a new region than are the grasshoppers. It is unlikely that any of these insects reproduce parthenogenetically, and therefore they are not particularly well adapted to the establishment of new colonies.

A consideration of the entire matter of transportation to and establishment on the North American continent of foreign insects must, it seems to the writer, lead to the conclusion that it is entirely a question of the biological fitness of a species; its ability to fulfil to a high degree the requirements for successful transportation and establishment in a new region. Those groups which are best fitted for transportation and establishment, such as the scale insects, are seen to have the greatest number of cosmopolitan species in proportion to number of species in existence, and those which are least fitted for these purposes, such as the Orthoptera, have the lowest numbers of cosmopolites.

There has been a tendency in the past on the part of biologists to attribute the establishment of foreign species to some unknown factor, to some deep, fundamental principle which remained obscure. There seems to be no reason why this feeling should apply to insects since there is abundant evidence to show that the particular hemisphere or particular coast, east or west, on which the insect originated has nothing to do with its establishment in North America. Neither does there seem to be any good reason for making a mystery out of the fact that the general tendency of dispersal seems to be from east to west, as from Europe to America. This could scarcely be otherwise when we consider the nature of the commercial intercourse. There is no doubt but that many more species have been introduced from Europe to America than from America to Europe. The reason for this seems plain enough, if we examine the statistics with reference to exchange of nursery stock between the two regions. I have been able to obtain figures for only one year, 1921, as given by the U. S. Department of Commerce. These indicate that during that year nursery stock was exported to the value of $352,000 and was imported to the value of $5,221,000, the ratio of exports to imports being as 1 to 14+. If we could obtain figures on the number of plants rather than the value there would be a far greater discrepancy, since European shipments include large numbers of seedlings of relatively small value, which are not grown in this country because of high labor costs. I believe that all entomologists agree that the importation of nursery stock is the most prolific source of new pests and that this great preponderance of imports over exports explains why we have received more pests from Europe than Europe has received from us. We need not look further than this for justification of the Federal Horticulture Board's quarantine No. 37.

The number of instances of successful transportation as compared to successful establishment must be very great. Undoubtedly such insects as the gipsy moth, the browntail moth, many of the boring insects and even the Mediterranean fruit fly have been brought to our shores many times. Of the two former and of many others of our foreign pests only a single instance of establishment from foreign sources is known. This is probably due to infertility of the females and to failure to land when and where environmental conditions are suitable for their propagation. It is only by a fortunate (from the insect's standpoint) combination of circumstances, which happens only rarely, that a foreign pest becomes established in a new habitat. It would seem, then, that if we are able to shut off the major portion of the opportunities of transportation of foreign insects to our shores we should be able to prevent their establishment almost indefinitely.

The shutting out of foreign nursery stock in view of what seems to be incontrovertible evidence of its responsibility for the establishment of most of our foreign pests in America is one of the

greatest steps which has ever been taken in preventive entomology. In a country like this, with such varied climatic conditions and a resourceful people, there seems to be no good reason why practically everything needed in the way of plants for propagation should not be produced somewhere on the North American continent, and thus reduce almost entirely the risk of additional introductions. To one accustomed to seeing thousands of Eucalyptus trees in California without a single insect attacking them, the knowledge that there are numerous serious pests of these trees in Australia is cause for congratulation that they were introduced in the seed stage rather than as nursery stock. It is a wonderful illustration of what quarantine can accomplish if we can do in practice that which is theoretically necessary to keep pests out.

Once a foreign pest has become established in our country, what should be the attitude of the economic entomologist? Should eradication be attempted, and if so, under what conditions? Apparently entomologists are not in entire agreement on this question. A few years ago the statement was occasionally made that once an insect became established, eradication was an impossibility. There certainly is no biological basis for such a feeling; there is no biological reason why any pest could not be eradicated, but whether or not it should be attempted must be decided only after careful consideration of the habits of the insect, the probable extent of the infestation and the economic factors, such as public support and financial backing. If, after carefully weighing these items, it appears that there is a reasonable probability of a successful outcome, it certainly would be economy in the long run to make the attempt. Entomological history is replete with instances where such opportunities presented themselves and were allowed to pass by. To the credit of the entomologists, however, it must be said that this failure can not be laid at their door. In 1894 the federal Bureau of Entomology sent an entomologist to Texas to investigate and report on a new cotton pest which had appeared along the Rio Grande. This entomologist urgently recommended, after thorough investigation, that "laws should be passed decreeing the Rio Grande border of Texas for a width of fifty miles to be a non-cotton-producing belt, compelling all persons to abandon the raising of cotton in that area, and providing for the destruction of all cotton plants (and other Malavaceae, if such exist) within the same." It is unnecessary to relate that this recommendation was not carried out. Whether or not it would have proved successful in preventing the stupendous damage later caused by the cotton boll weevil can not, of course, be determined, but so far as I know there is no biological reason why it should not have succeeded. Not long ago I read a statement from a Louisiana paper quoting a banker as saying that "at last the entomologists are beginning to realize that the cotton boll weevil is a serious pest." It was this same type of mentality that opposed the carrying out of the above recommendations of the entomologists.

In 1889 the gipsy moth, well known at that time as a serious pest in Europe, was confined to an area of one and one half miles long by one half mile in width at Medford, Massachusetts. At that time Professor Fernald recommended its extermination, and Riley and Howard, of the Bureau of Entomology, urged that "it can be entirely killed out with the expenditure of a little time and money." Support for this idea was not forthcoming, however, and since then millions and millions of dollars have been expended simply in an effort to check its spread, with no end in sight. Biologically, the eradication of an insect

of habits like the gipsy moth, which exists solely in the egg stage for many months and in which the female does not fly, should have been easily possible over such a comparatively small area. Examples of this kind might be multiplied but it is unnecessary. There are without question many cases of introduction of pests in which an eradication attempt would be inadvisable, but where for a considerable portion of the year there are no adults flying and the habits are such that the other stages are easily destroyed by thorough work and the known distribution is not too great such an attempt would be well worth while. Naturally a thorough knowledge of the habits and distribution of the pest must be had before a safe decision can be reached, but, when a careful weighing of biological and economic factors indicates that there is a reasonable probability of success, entomologists should not hesitate to urge this action. Millions of dollars have recently been spent in California in the successful eradication of the foot-and-mouth disease, and a similar campaign against newly established pests of habits favorable to eradication would be equally justifiable.

Introduced pests which have become firmly established in our fauna often present possibilities of biological control which should not be overlooked. This method, of course, has its limitations, but full advantage should be taken of any opportunity to help reestablish the balance disturbed by introduced species, thus preventing damage and delaying spread. In the case of those species for which no satisfactory method of control has been developed, parasite introduction becomes an absolute necessity.

It is obvious, then, that the duty of governments, so far as applied entomology is concerned, lies in following this program: *quarantine*, to exclude insect pests which have not yet been introduced or which are of very limited distribution; *eradication*, applied to those individual cases where an introduced pest is of very limited distribution and where a careful biological and economic study of the conditions gives reasonable hope of success; *biological control*, to reduce the population of an insect pest below the danger line or to reduce it to the point where mechanical methods give more perfect results, and finally, as an additional safeguard, to develop the *mechanical* and *cultural methods* of control to the highest possible degree of perfection.

There is nothing which is more indicative of the progress of the profession of applied entomology than the increased attention which is being paid to preventive methods. Quarantine, eradication and biological control are coming to the forefront, thus paralleling, in a way, the development in medicine, the greatest of all biological professions. Preventive entomology requires not only advanced technical skill and a knowledge of insect ecology, but it requires also a high grade of organizational ability. Fortunately, because of continual contact with economic problems, both these characteristics are to be found in an increasing degree in the membership of the entomological profession.

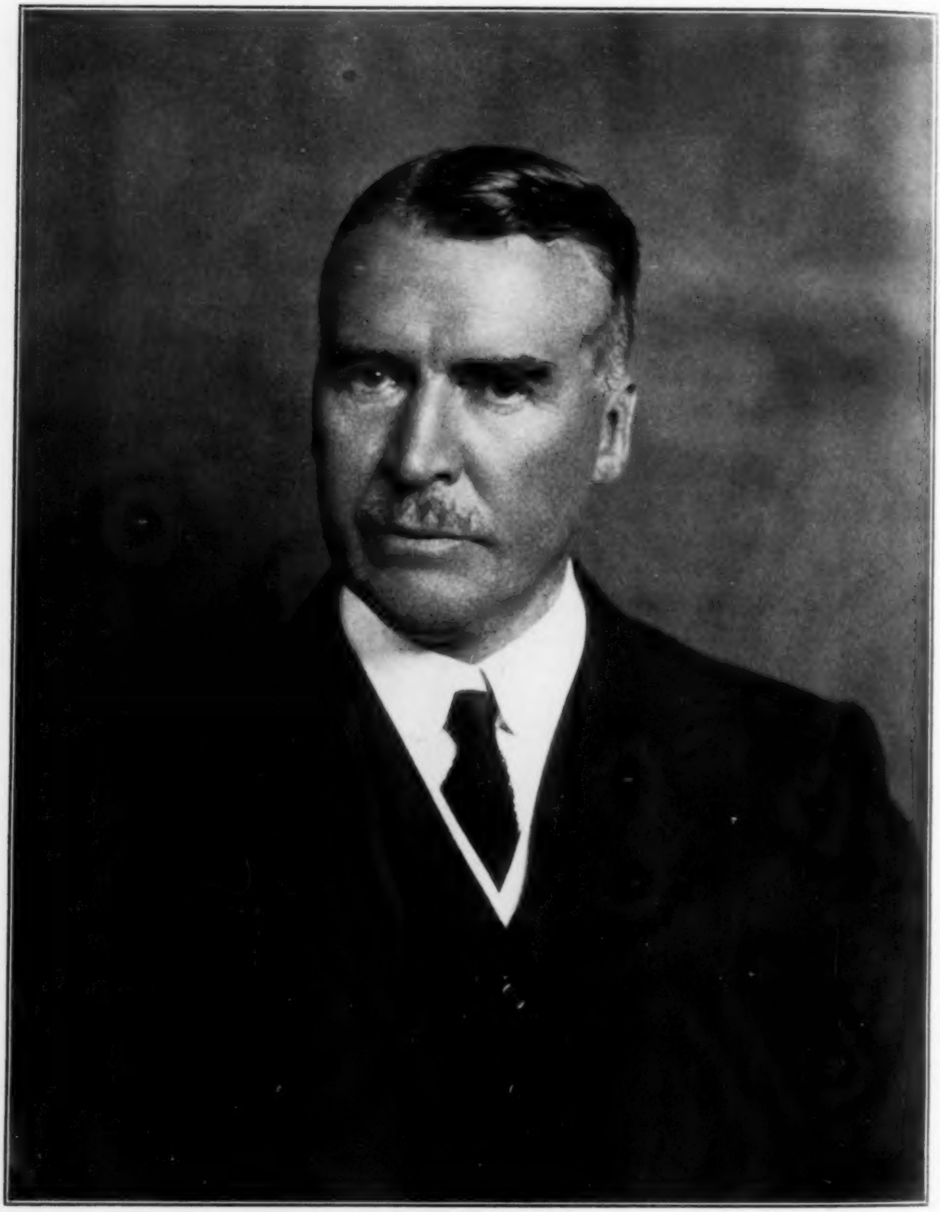
THE PROGRESS OF SCIENCE

THE BRITISH ASSOCIATION IN SOUTH AFRICA

THE British Association for the Advancement of Science normally holds its annual meetings in successive centers in the United Kingdom. Its meeting-places are not chosen in rotation, but depend upon invitation, from the municipal councils, universities and other appropriate authorities; and such invitations during the ninety-eight years of the association's existence have never been lacking. And from time to time the call comes from one of the dominions, and the association, in answering it, fulfills a duty peculiar to itself. As in the course of years world-travel has become easier and quicker, it has come about that many congresses, national and international, have been organized in the dominions of the British Empire to meet the interests of special branches of science and industry, and to bring together from all over the world experts in some one particular sphere of interest. But the British Association brings all departments of science within its scope and affords a unique opportunity for intercommunication between them. Meetings overseas, moreover, allow scientific workers in every field, from the homeland or from foreign countries, to meet their colleagues in the dominions. America has had experience of this through the meetings of the association in Montreal (1884), Winnipeg (1909) and Toronto (1897 and 1924). At the last Toronto meeting the British visitors welcomed a large number of American fellow-workers who crossed the international boundary to join them. At earlier Canadian meetings the same thing had happened; and many of the British men of science took the opportunity to visit their colleagues in the United States, to enjoy their hospitality and to make personal acquaintance with the seats of learning and the natural scientific interests of the country. The famous Baltimore lectures by Sir William Thomson, afterwards Lord Kelvin, given at the instance of the authorities of the Johns Hopkins University, followed after the Montreal meeting of the association in 1884, at which Rayleigh was president. Moreover, Thomson and other British representatives were enabled to be present at the meeting of the American Association in Philadelphia; and 1884 has been since described as "a wonder-year of scientific conference between physicists of the old world and the new." And this is but one example.

When the association met in South Africa in 1905, 380 visiting members made the journey overseas. The main meetings were held at Cape Town and Johannesburg, and official visits were also paid to Durban, Pietermaritzburg, Pretoria, Bloemfontein, Kimberley, Bulawayo and other centers, and also to the Victoria Falls, where the president of the association, Professor (afterwards Sir) George Darwin, opened the railway bridge.

The meeting this year will follow similar lines. It begins in Cape Town on July 22, the opening function being made the occasion for an address by Mr. J. H. Hofmeyr, administrator of the Transvaal and president of the South African Association for the Advancement of Science, the inviting body, which will merge its annual meeting with that of the British Association. The visiting party proceeds on July 28–29 by way of Kimberley, where it will be entertained by the De Beers Consolidated Mines Company, to Johannesburg. Here, on July 31, Sir Thomas Holland delivers his presidential address. Special opportunities for coop-



SIR THOMAS HOLLAND

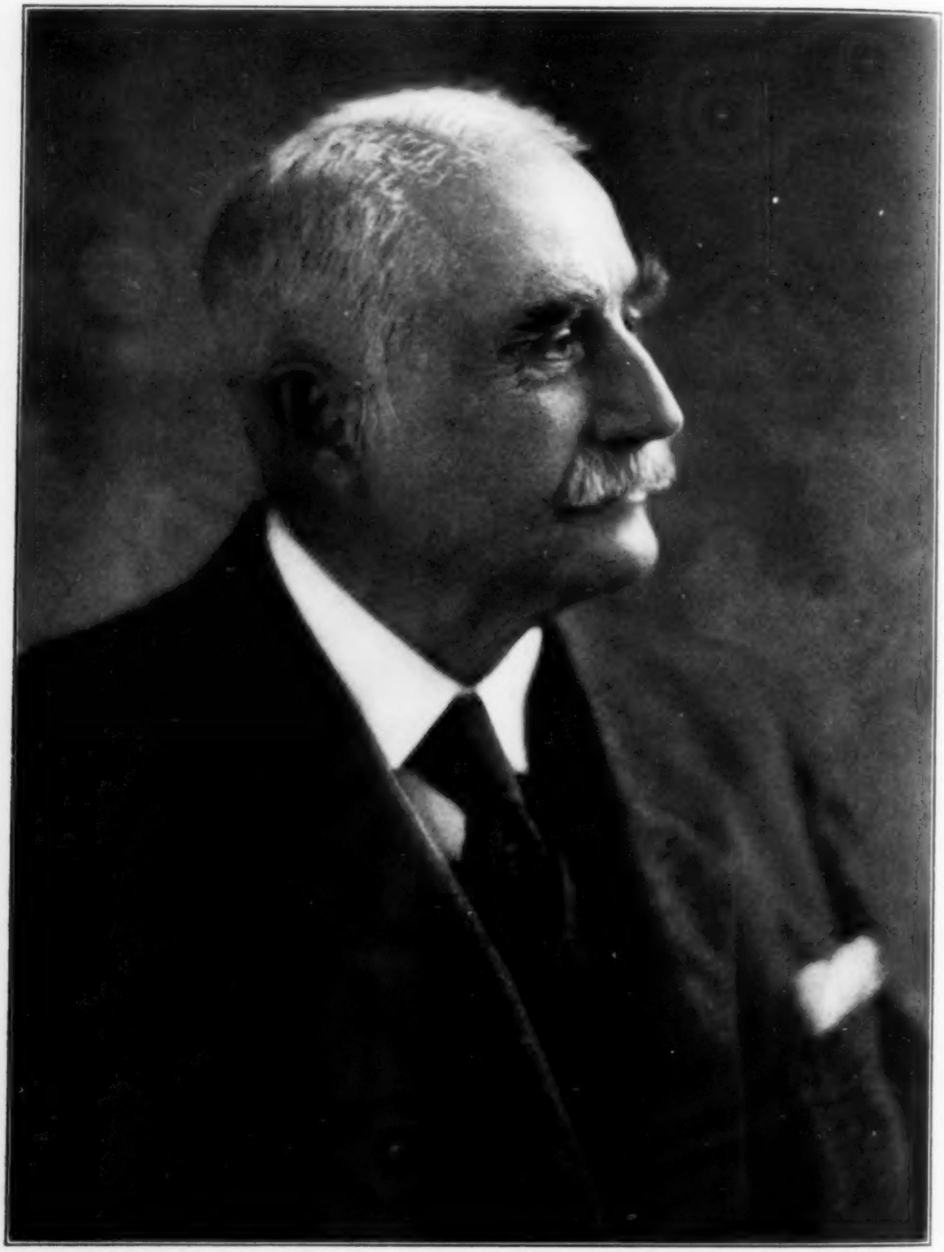
PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. RECTOR OF THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON, AND PREVIOUSLY PROFESSOR OF GEOLOGY AND MINERALOGY IN THE UNIVERSITY OF MANCHESTER.

eration will be afforded between the association and the International Geological Congress in Pretoria and a Pan-African and Departmental Agricultural conferences in the same city. All the sections of the association will hold meetings in Cape Town and in Johannesburg, and the various scientific interests of these cities and their neighborhoods will be explored. After the meetings in Johannesburg and Pretoria, most visiting members will take advantage of one or other of a series of tours which are offered by the travel and tourist department of the South African Railways. These will give occasion for visits to several of the other important cities of the Union, such as Durban, Bloemfontein and Pietermaritzburg, and it is likely that lectures will be given in these places and elsewhere by distinguished scientific visitors. Parties also are expected to proceed to Lourenço Marques in Portuguese Territory, to Rhodesia and the Victoria Falls, with calls at Bulawayo and the antiquarian remains at Zimbabwe. These last are to be reinvestigated in advance, and an important report upon them is expected at the meeting. Lastly a selected party will visit the colony of Kenya by invitation of its government. Arrangements so comprehensive can not fail to leave a permanent mark upon the development of scientific research in South and East Africa, and (speaking more generally) to alleviate that sense of remoteness and aloofness which even yet, in the minds of so many people, attaches to southern Africa.

FURTHER PROGRESS IN CRYSTAL ANALYSIS

In an address before the Royal Institution of Great Britain, Sir William Bragg, Fullerian professor of chemistry at the institution, explained that alloys have played a great part in the history of mankind. The qualities of pure metals are rarely desirable, but the properties of alloys cover a far wider range, within which can be found every variety of usefulness. Pure copper is too soft for most purposes, but when varying quantities of tin are introduced the bronzes so formed have many applications. At one stage of human development bronze was all-important. It is still largely used. The copper coinage is only slightly alloyed; the useful "gun-metal" contains a larger quantity of tin; bell-metal contains more, and speculum or mirror-metal more still. Small quantities of other substances, especially zinc, are often inserted into bronzes; and the influence of minute quantities of such foreign substances is remarkable. Since many substances can be used in making alloys, two or more at a time, and since even minute quantities of a component often change the properties entirely, it will readily be understood that the possible variations are almost infinite. Among these metallurgists seek for those which can be put to practical use. Great advances have been made in recent years, and such terms as chrome steel, manganese steel, duralumin and the like, have become common.

The reasons for this variety are most obscure, and great interest attaches to any method which can help to bring order and understanding into the complexity. The X-rays have come to give assistance of a novel kind. They reveal the modes in which the atoms are arranged in solid substances, provided that any regularity of arrangement exists, and in general this is the case. It turns out that the atoms in the different phases of a mixture are put together according to different patterns, and the properties of the substances are obviously connected with the pattern. In pure copper the atoms are piled together in close packing, like spherical shot; each sphere then touches twelve neighbors. When a small number of zinc atoms are added they distribute themselves at ran-



—Photograph by Frank Moore.
Courtesy of the American Institute of Electrical Engineers

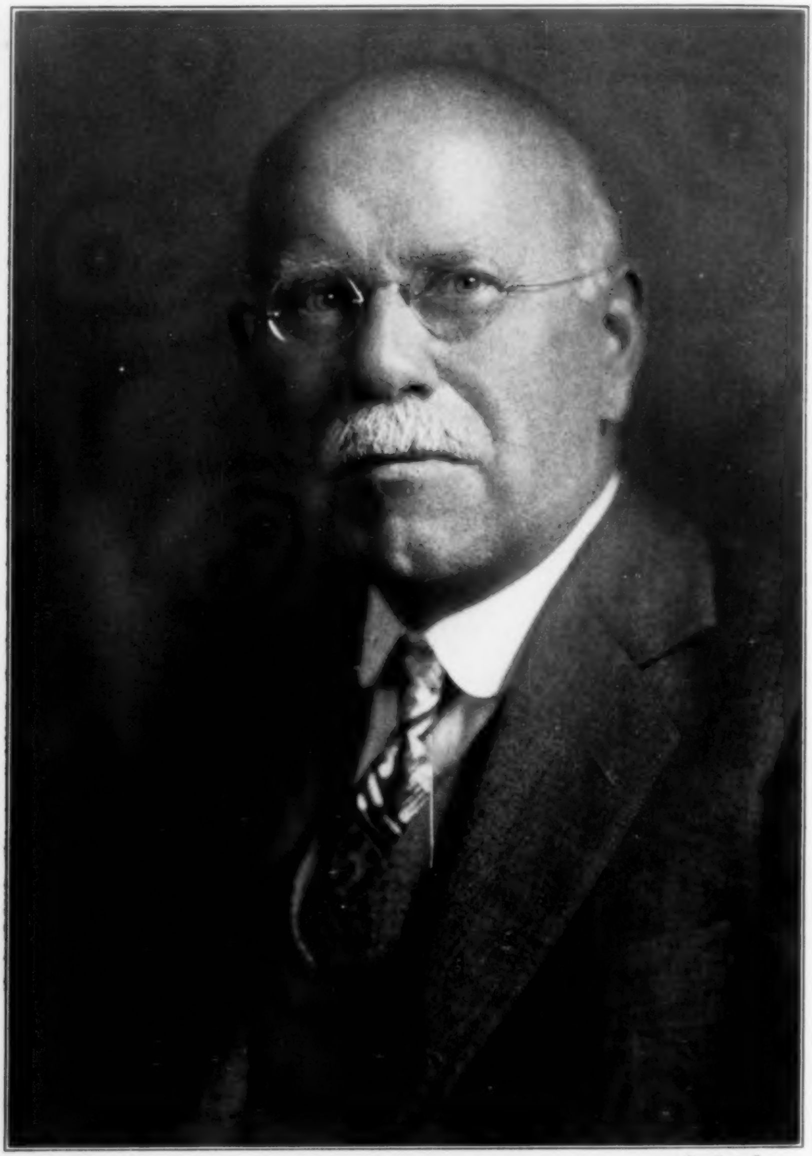
CHARLES FRANCIS BRUSH

DISTINGUISHED FOR HIS WORK IN THE DEVELOPMENT OF ELECTRIC ARC LIGHTING, WHO DIED AT HIS HOME IN CLEVELAND, ON JUNE 15, AT THE AGE OF EIGHTY YEARS.

dom amongst the copper atoms without disarranging the pattern very much. But there is a limit to this addition. If too much zinc is put in a new pattern is formed, in which each atom now has only eight neighbors. Next comes a remarkable change as more zinc still is put with the copper. A very complicated pattern is formed of which the unit is twenty-seven times as large as in the preceding case, and there are fifty-two atoms in it. This alloy is very hard and brittle. Curiously enough there is an alloy of copper with aluminium, and again of copper with tin, in which the same properties are exhibited, the same pattern is found, and the same number of atoms in the pattern. Moreover, what is still more interesting is that there is the same number of free electrons. The free electrons are those which a metal can shed comparatively easily: a zinc atom can shed two, an aluminium atom three and a tin atom four. These curious alloys are composed of five atoms of copper to eight of zinc, nine of copper to four of aluminium, and the third, very approximately, in the ratio of thirty-one of copper to eight of tin. In each case there are thirteen atoms to twenty-one electrons.

Professor Bragg says that these new results, which are most interesting from all points of view, are due mainly to the work of Owen and Preston, Bradley, and Bernal in England, Westgren and Phragmen in Sweden. They open up new ideas of the conditions in the alloy. They suggest that we ought not merely to think of an alloy as a mixture of atoms, but in some cases at least as a mixture of electrons with atoms, the latter having considerable latitude as to nature. Somewhat similar conclusions have been reached in regard to the silicates composing by far the major part of the earth's crust.

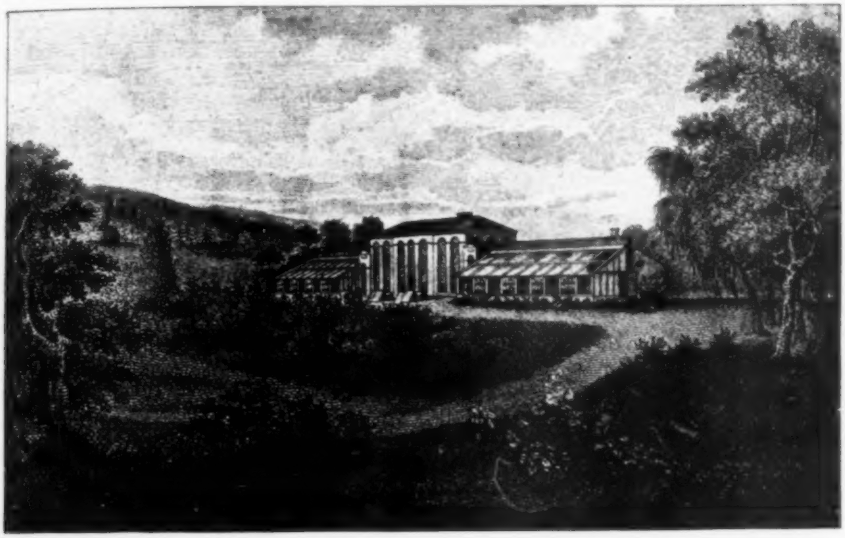
In a different direction an important step forward has been made in Mrs. Lonsdale's (Miss Yardley) determination of the disposition of the atoms in the organic compound hexamethyl benzene. The application of the X-ray methods to organic structures has always been very tempting, because the properties of the organic molecule depend so remarkably on the mutual arrangement of the atoms of which it is composed. This has of course been long known, and it has been found possible to arrive at some knowledge of the particular designs by studies of the chemical reactions peculiar to them. But the X-rays may be expected in the end to furnish quantitative, as against qualitative, details of the molecular structure, and to give the relative positions of the atoms in space. The long chain compounds, which constitute a very important section of the organic substances, have already been attacked with success, but the other important section, consisting of substances founded on the benzene ring, have not hitherto proved so amenable. They are more complicated, and their analysis is more difficult. If any one of them can be worked out in detail the whole problem will be simplified. It appears that Mrs. Lonsdale's solution in the case of hexamethyl benzene has actually provided this initial success. The molecule consists of the hexagonal benzene ring of carbon atoms, to each of which is attached a methyl group (CH_3). The unit of pattern contains only one molecule. It is triclinic, that is to say, there are no planes or axes of symmetry; there is, however, a center of symmetry. As there is only one molecule in the unit cell, this center is found in the molecule itself, the only symmetry which it possesses. In certain ways the cell very nearly possesses other symmetries, and by a skilful use of these approximations as measured by the curious effect which they have on the relative intensities of reflection by different sets of planes within the crystal, Mrs. Lonsdale has been able to place every carbon atom in the molecule.



—*Bachrach*

JOHN WILLIAM HARSHBERGER

INSTRUCTOR AND PROFESSOR OF BOTANY IN THE UNIVERSITY OF PENNSYLVANIA FROM 1892 UNTIL HIS RECENT DEATH. AN ARTICLE BY PROFESSOR HARSHBERGER ON FACILITIES FOR BOTANICAL INVESTIGATION IN SOUTH AMERICA WILL BE FOUND IN THE PRESENT ISSUE OF THE SCIENTIFIC MONTHLY.



COLUMBIA UNIVERSITY AND THE ELGIN BOTANICAL GARDENS

LAND that was the site of America's first botanic gardens, the Elgin Botanical Gardens, erected in 1804 by Professor David Hosack, a man considered a little queer and his project listed in those days as a folly as many early scientific efforts were considered, will in 1938 be producing an annual income of approximately $3,000,000 to Columbia University. For the use of this income the university already has planned.

This income will result from the lease to John D. Rockefeller, Jr., of property owned by the university between 48th and 51st Streets and extending from Fifth Avenue to within 100 feet of Sixth Avenue. The contract, dating from last October, provides for a lease of twenty-four years, and three renewals of twenty-one years each. The annual income eventually will be approximately $3,000,000 as compared to about $300,000 which the university has been receiving from 203 separate leaseholds. It is proposed to use part of this property as a site for a new opera house and the remainder for a modern shopping center. The details of this project remain to be worked out.

Although the lease with Rockefeller dates from last October, Columbia University will not realize the full income for a period of years owing to the fact that it has not yet been able to acquire all of the previous leaseholds, some of which have until 1938 to run.

In acquiring leaseholds that had not expired, the university has already borrowed $6,000,000 which must be repaid out of the income. Concerning the disposition of the remainder of the income, President Nicholas Murray Butler made the following statement at the time of the announcement of the Rockefeller lease: "In anticipation of an increased income from this property at about this time, the trustees of the university had already incurred debts and budget obligations which would absorb all the increased income for some time to come. The greatly increased salary schedule for all academic officers, adopted in April last (1928), the much greater cost of maintaining the work of the medical school at the new medical center, and repayment of amounts borrowed to construct the costly research laboratories for the physical and chemical sciences

which were completed last year will require the use of the new income for several years."

The recently completed laboratory buildings to which Dr. Butler referred are the new fourteen-story physics building which houses the departments of physics, astronomy and optometry, and the eleven-story annex to Havemeyer Hall which provides additional laboratory facilities for the department of chemistry and the department of chemical engineering. Now under construction is an eleven-story addition to Schermerhorn Hall to be erected at a cost of $1,000,000. This new addition will house additional facilities for zoological and botanical research.

In addition to these buildings at Morningside Heights, Columbia is a partner in the Medical Center project which is valued at $21,000,000 and which includes the schools of medicine and of dental and oral surgery. Large research plans were instituted in both of these schools last fall when they moved into their new quarters.

The plot of ground which is to provide an income to aid in the maintenance of research plans at Columbia was the location of the Elgin Botanical Gardens from 1804 to 1810. Professor David Hosack, one time a student at Columbia, later professor of botany there and then professor of materia medica at the College of Physicians and Surgeons, established the garden and within two years had 2,000 rare botanical specimens growing there. In 1810 he was forced to sell the plot to the state because of inability to gain either college or state aid for the gardens.

The land leased to Rockefeller is part of the tract which Columbia acquired in 1814, at a time when other New York colleges benefited by cash gifts from state lotteries. The Reverend John M. Mason, at that time president of Columbia, was roundly criticized for accepting the land in lieu of a cash gift, because, his critics said, the land was worth nearer $6,000 than the $80,000 at which the state then valued it. It was not until the 1850's that the university began to realize the value of the land. Prior to that time, it had failed to gain a fair return on leases, and had been forced to borrow large sums to meet the cost of street improvements.

About this time, some of the trustees realized the possibilities of the land, and it was laid out in city lots. Sixteen of these lots were disposed of to the Dutch Reformed Church for $80,000 in 1857, and in 1904 the part of the site lying between 47th and 48th Streets was sold for $3,000,000. The remainder of the property has steadily grown in value and has produced a large income from ground leases.